NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

(NASA-CR-147638) RESULTS OF TESTS CS4 AND CS5 TO INVESTIGATE DYNAMIC LOADS AND PRESSURES ON 0.03-SCALE MODELS (AX1319-3/4 AND 45-0) OF MATED 747 CAM AND SPACE SHUTTLE ORBITER IN THE BOEING TRANSONIC WIND TUNNEL G3/16

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SPACE SHUTTLE

AEROTHERMODYNAMIC DATA REPORT

JOHNSON SPACE CENTER

HOUSTON, TEXAS

DATA MANagement services

SPACE DIVISION CHRYSLER CORPORATION

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RESULTS OF TESTS CS4 AND CS5 TO INVESTIGATE DYNAMIC LOADS AND PRESSURES ON 0.03-SCALE MODELS (AX1319-3/4 AND 45-0) OF MATED 747 CAM AND SPACE SHUTTLE ORBITER IN THE BOEING TRANSONIC WIND TUNNEL

by

747 Aeroloads and Wind Tunnel Test Group
Boeing Aero Space Company

Prepared under NASA Contract Number NAS9-13247

by

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for

Engineering Analysis Division

Johnson Space Center
National Aeronautics and Space Administration
Houston, Texas

WIND TUNNEL TEST SPECIFICS:

Test Number:	BTWT 1490 and 1493
NASA Series Number:	CS4 and CS5
Model Number:	AX1319-3 and AX1319-4 Carrier, 45-0 Orbiter
Test Dates:	September 29 through October 2, 1975 (CS4) and November 3 and 4, 1975 (CS5)
Occupancy Hours:	64 (CS4) and 33 (CS5)

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ABSTRACT

A 0.03-scale model of the 747 CAM/Orbiter was tested in the Boeing 8 x 12-foot Transonic Wind Tunnel. Dynamic loads, pressure, and empennage flow field data were obtained using pressure transducers, strain gages, and a split film anemometer. The test variables included Mach number, angle of attack, sideslip angle, orbiter tailcone on and off, orbiter partial tailcone, orbiter nozzle air scoops, orbiter body flap angle, and orbiter elevon angle.

TABLE OF CONTENTS

INDEX OF FIGURES

INDEX OF FIGURES (Continued)

INDEX OF FIGURES (Concluded)

INTRODUCTION

Previous 747 CAM/Orbiter mated configuration buffet testing was accomplished in the Boeing Transonic Wind Tunnel (BTWT) in September 1974 (CA5, References 1 and 2) and June 1975 (CS2, Reference 3) and in the University of Washington Aeronautical Laboratory (UWAL) in June 1975 (CS1, Reference 4). These tests showed the 747 vertical tail buffet loads were much larger with the orbiter tailcone off than with the orbiter tailcone on.

A wind tunnel test was run at Texas A&M in August 1975 (CA16A) to investigate alternate configurations (other than tailcone on) which might reduce the 747 vertical tail buffet loads. Two potential alternate configurations emerged from this test—one with orbiter nozzle air scoops and one with a partial tailcone. Two additional wind tunnel tests were then planned to investigate more fully these configurations. One was a low speed test at UWAL (CS3, Reference 5) which was run in September 1975 utilizing a low speed flutter model. The other was a high speed test at BTWT (CS4, Reference 6) which was run in September 1975 utilizing a rigid force model.

The AX1319-3 and AX1319-4 0.03 scale models of the 747 CAM mated with the Rockwell International 45-0 orbiter model were tested in the Boeing 8 x 12 foot Transonic Wind Tunnel during test CS4. The objectives of the CS4 test were (1) evaluate the buffet characteristics of the 747 CAM/Orbiter with orbiter nozzle air scoops, partial tailcone and body flap position, (2) measure the orbiter wake with a split film

probe, and (3) gather data for use in a buffet loads computer program. These objectives were accomplished. The first objective was accomplished by conducting a trade study of configuration variables and orbiter body flap positions at M = 0.5. An abbreviated Mach series was conducted only for a limited number of the configurations. Analysis of the measured vertical tail RMS pressure coefficients indicated minor variations with Mach number for all configurations except the air scoops. The air scoops were effective at all Mach numbers except at M = 0.5, where the effectiveness degraded significantly. Evaluation of the measured vertical tail RMS bending moments showed that the air scoops were effective at low Mach numbers but were ineffective at Mach number 0.5 and above. Since the preponderance of the test data was at M = 0.5, efforts to determine the data validity were made for these runs. In addition to the standard instrumentation checks, cross correlations between the various vertical tail pressure pickups showed consistency in the data between the air scoops' on and off configuration. These checks verified the basic conclusion that the air scoops lost their effectiveness at M = 0.5.

After reviewing the CS4 data, the customer directed that an additional test be conducted immediately to eliminate the data questions and to attempt to define a more feasible tailcone off air scoop configuration. Therefore, the CS5 test was conducted in November 1975 with the test objectives (1) to determine the aerodynamic effectiveness of the nominal air scoops as a function of Mach number, (2) to determine if a

variation of the air scoops parameter (size and attitude) would increase their aerodynamic effectiveness at M = 0.5, and (3) to determine the optimum orbiter body flap setting for the tailcone off (no air scoops) configuration. These objectives were met and the test results verified the original CS4 conclusion. The nominal air scoops rapidly lost their effectiveness above M = 0.35, but the large area (12 FT^2) scoops were effective up to M = 0.55. The test data for the third objective showed that the lowest differential pressure coefficients on the fin without any air scoops were obtained with either a body flap angle of -5° or -11.7°. These levels are approximately the same as measured with the nominal area (6 FT^2) scoops at M = 0.5.

The final evaluation of the buffet characteristics of the 747 CAM/ Orbiter, as derived from the above two rigid model high speed tests, is summarized in this report. The contents of this report were derived from References 6, 7, and 8, which contain detailed information describing CS4 and CS5 results.

NOMENCLATURE

Symbol	Definition
A_{SC}	Scoop Area, Square Feet
B.L. (B.P.)	Buttock Line (Buttock Plane)
BTWT	Boeing Transonic Wind Tunnel
C	Chord, Inches
CAM	Carrier Aircraft Modification
℄	Centerline
$\overline{HT}_{i-j}$	RMS Differential Pressure on the 747 Horizontal Tail
i_o	Orbiter Incidence, Degrees
i_{SC}	Scoop Incidence, Degrees
KEAS, V_e	Knots Equivalent Air Speed
M	Mach Number
psi	Pounds Per Square Inch
$\Delta\overline{P}$	RMS Differential Pressure
q, Q	Dynamic Pressure
$R_{\Delta P \times \Delta P}$	Pressure Cross Correlation Coefficient at Zero Time Lag
RMS	Root Mean Square
δ_{SC}	Scoop Radial Measurement, Model Scale Inches
T.C.	Tailcone
$\overline{TF}_{i-j}$	RMS Differential Pressure on the 747 Tip Fin
UWAL	University of Washington Aeronautical Laboratory
W.L.	Waterline
R_{SC}	Scoop Radial Measurement, Full Scale Inches

NOMENCLATURE (Continued)

Symbol	Definition
u'_r, u'_ϕ	Fluctuating Velocities in the Radial and Angular Probe Coordinate Directions
u'_x, u'_y, u'_z	Fluctuating Velocities in the Longitudinal and Transverse Model Coordinate Directions
$\overline{u'^2_r}$, etc.	Mean Square Values of Turbulence
V_L	Local Mean Velocity
U_∞	Free Stream Velocity
V_A	Design Maneuvering Speed
V_B	Design Speed for Maximum Gust Intensity
V_C	Design Cruise Speed
V_D	Design Dive Speed
V_E	Equivalent Air Speed
$\overline{V}_{i-j}$	RMS Differential Pressure on the 747 Vertical Tail
$\frac{x}{c}$	Chordwise Location
X, Y, Z	Longitudinal, Spanwise and Vertical Dimensions
Z_{tip}	Height of 747 Vertical Tail
α_B	747 Body Angle of Attack, Degrees
α_{ENC}	Uncorrected 747 Body Angle of Attack, Degrees
α_W	747 Wing Angle of Attack, Degrees ($\alpha_W = \alpha_B + 2$)
β	Sideslip Angle, Degrees ($\beta = -\psi$)
δ_{BF}	Orbiter Body Flap Angle, Degrees
δ_e	Orbiter Elevon Angle, Degrees

NOMENCLATURE (Concluded)

Symbol	Definition
δ_{SB}	747 or Orbiter Speed Brakes
η	Spanwise Location
η_T, η_H, η_V	Spanwise Location for the Tip Fin, Horizontal and Vertical Tail
θ_y, θ_z	Crossflow and Upflow, Positive Up and Outboard
ϕ, r	Probe Coordinates in the Angular and Radial Direction
ϕ_{SC}	Scoop Roll Angle, Degrees
ψ	Yaw Angle, Degrees
δ_{FRL}	747 Horizontal Tail Incidence Angle, Degrees
B.S.	Body Station
$\bar{c}$	Mean Aerodynamic Chord (MAC)
IML	Inner Mold Line
LE	Leading Edge
OML	Outer Mold Line
OMS	Orbital Maneuvering System
PSD	Power Spectral Density
TE	Trailing Edge
WBL	Wing Buttock Line
W.P.	Water Plane
X_o, Y_o, Z_o	Orbiter Longitudinal, Spanwise, and Vertical Dimensions Reference System
$r\phi/Z_{tip}$	Arc Length Parameter

CONFIGURATIONS INVESTIGATED

The model was an 0.03 scale representation of the space shuttle orbiter and 747 CAM (NASA 905) aircraft. Both mated and isolated carrier configurations were tested. The mated orbiter and carrier configuration is shown in Figure 2a. This arrangement was tested with tailcone removed as shown in Figures 3c and d, with a partial tailcone as shown in Figure 3e and with tailcone on the orbiter as shown in Figures 3f and g. Tail-cone-off testing was done both with and without air scoops as shown in Figures 3j and 3k. Figure 3l shows the tailcone and Figures 3n and 3o show the attach hardware used to mount the orbiter on the carrier. Figure 2c shows the orbiter configuration. The isolated carrier was also tested in both CAM Type 1 and CAM Type 2 arrangements as shown in Figures 3a and 3b, respectively. Figure 2b defines the basic 747-100 configuration. Carrier tip fins are shown in Figure 3m. The carrier model was designated AX1319-3 and the oribter model was designated 45-0.

The model configurations tested in each run are identified in Table II. These configurations are abbreviated as:

$747 = W_{44.1}\ B_{27.8}\ M^{25}_{26.8}\ N^{57}_{58}\ T_{19}\ X_{18.4}\ H_{15.1}\ V_{9.1}\ TS\#1$

$747\ W/CAM = 747 - H_{15.1} + H_{15.6} + AT^{103.4}_{105}$

$MATED = 747\ W/CAM + W_{116}\ B_{26}\ C_9\ E_{43}\ V_8\ R_5\ M_{16}\ F_8\ N_{28}\ N_{24}$

$MATED\ W/TC_{19.1} = MATED + TC_{19.1}$

$MATED\ W/TC_{19.2} = MATED + TC_{19.2}$

$MATED\ W/SC_1 = MATED + SC_1$

$MATED\ W/SC_2 = MATED + SC_2$

CONFIGURATIONS INVESTIGATED (Continued)

MATED W/SC_1 & PROBE = MATED - $H_{15.6}$ $V_{9.1}$ with hot wire probe installed

Where individual model components are defined as:

747 Component	Description
$AT_{103.4}$	forward orbiter attach strut
AT_{105}	aft orbiter attach strut
$B_{27.8}$	fuselage
$H_{15.1}$	horizontal tail
$H_{15.6}$	horizontal tail with 200 ft^2 tip fins
M_{25}	inboard Nacelle struts
$M_{26.8}$	outboard Nacelle struts
N_{57}	inboard Nacelle
N_{58}	outboard Nacelle
T_{19}	flap track fairings
TS#1	boundary layer transition strip: Horizontal and vertical tail and wing upper and lower surfaces have No. 120 grit at 80 to 100 grams per inch, 0.1 inch wide at 10% of local chord. Fuselage has No. 100 grit 80 to 100 grits per inch, 0.1 inch wide located 0.75 inch aft of nose tip. Nacelles have No. 100 grit 80 to 100 grits per inch, 0.10 inch wide 0.4 inch aft of leading edge on both inside and outside.
$V_{9.1}$	vertical tail
$W_{44.1}$	wing
$X_{18.4}$	wing-body fairing

CONFIGURATIONS INVESTIGATED (Concluded)

Orbiter Component	Description
B_{26}	fuselage
C_9	canopy
E_{43}	elevon
F_8	body flap
M_{16}	OMS pod
N_{24}	main propulsion nozzle
N_{28}	OMS nozzle
R_5	rudder
SC_1	air scoop with 6.85 ft^2 area
SC_2	air scoop with 13.7 ft^2 area
$TC_{19.1}$	tailcone with vents
$TC_{19.2}$	partial tailcone
V_8	vertical tail
W_{116}	wing

MODEL INSTRUMENTATION

Instrumentation consisted of 34 Kulite pressure transducers, 4 strain gages. and a split film probe. The general locations of the pressure transducers and strain gages are shown in Figure 2d. The pressure transducers were mounted back to back on the 747 empennage. The 747 vertical tail had 7 pairs (14 transducers) and the 747 horizontal tail had 6 pairs (12 transducers) as shown in Figure 2g. The 747 tip fins had 2 pairs (4 transducers) as shown in Figure 2f. Four transducers were mounted on the 747 aft fuselage as shown in Figure 2e. The strain gages were mounted at the roots of the orbiter vertical tail, the 747 vertical tail, and the 747 left and right horizontal tails. The split film probe set up is shown in Figure 2h. Data from the pressure transducers, strain gages, and the split film probe were recorded on magnetic tape (FM mode) during the test. The 747 vertical tail was off when the split film probe was installed. The probe traversed radially and angularly at 2 longitudinal positions to determine the wake characteristics behind the orbiter as shown in Figure 2i. The longitudinal and tangential velocity components were measured with the probe in one orientation. The probe was then rotated 90 degrees and the run repeated to measure the radial velocity component.

Probe position is denoted as follows in Table II:

MODEL INSTRUMENTATION (Concluded)

DESIGNATION	ORIENTATION AT 0° ROLL	ROLL	TRAVEL
V_1	Vertical	65.96	14.01
V_2		74.52	13.28
V_3		98.06	12.92
V_4		84.2	12.8
V_5		85.1	8.298
V_6		82.6	8.298
H_1	Horizontal	65.96	14.01
H_2		74.52	13.28
H_3		98.06	12.92
H_4		84.2	12.8
H_5		85.1	8.298

TEST FACILITY DESCRIPTION

The Boeing Transonic Wind Tunnel (BTWT) is a continuous flow, closed circuit, single return, atmospheric facility with the following characteristics:

Test Section Flow Parameters		Test Section Dimensions	
Freestream Condition	Range	Description	Value
Mach number	0 thru 1.15	Cross-Section (minus corner fillets), ft.	8 x 12
Dynamic pressure. psia	0 thru 6.3		
Static pressure, psia	15 to 5.4	Length, ft.	14.5
Stagnation pressure	atmospheric	Area, ft.^{2}	88
Maximum unit Reynolds number, per foot	4×10^6		
Maximum total temperature, $^\circ$F	160		

The test section can be operated with either solid or slotted walls. The slotted wall configuration consists of 16 slots which can have wall porosity of 3.5% or 11%.

TEST PROCEDURE

The 747 CAM model was installed on an offset sting from the rear of the model. The orbiter model was mounted on the 747 CAM through a three-point strut support system. Kulite pressure transducers were used to measure the fluctuating pressures on the 747 CAM empennage and aft body. Strain gages were used to measure the 747 CAM horizontal and vertical tail root bending moments. Figure 2d summarizes the model instrumentation.

In CS4 the majority of the configurations were evaluated by running an angle of attack series at a fixed M = 0.5 with only limited testing at other Mach numbers. In CS5 the majority of the configurations were evaluated by running a Mach series at a single angle of attack. The Mach numbers and corresponding tunnel speeds investigated are shown in Table II. Figure 2j summarizes the flight conditions that were simulated.

Mated Orbiter wake surveys were made using a model-mounted survey mechanism. This mechanism, shown schematically in Figure 2h, was remotely operable in two dimensions allowing radial and angular position variation around an axis parallel to the 747 body centerline and was manually adjustable longitudinally. Photographs of the probe mounted in BTWT are shown in Figures 3h and i. The probe used on the survey mechanism was a split film anemometer which allowed simultaneous measurement of mean flow velocity normal to the film, flow angle normal to the film, and the two components of fluctuating velocity normal to

the film. Repeat measurements with the probe rotated 90° allowed evaluation of all three components of velocity. Both the vertical and horizontal stabilizers were removed from the 747 model while the wake surveys were made to facilitate movement of the probe. Only the tailcone off with scoops on configuration was surveyed.

Two types of surveys were made. First, the probe was placed at a fixed model position at the tip fin and at the horizontal tail. Then the model was swept slowly through an angle of attack range. Second, the model was placed at 6° angle of attack and the probe was moved around a path in the wake of the orbiter base at the 747 vertical stabilizer. The fixed positions and the path are shown on Figure 2i.

DATA REDUCTION

The total data acquisition system consisted of three tape recorders and the Wind Tunnel Astrodata System. The tape recorders recorded the signals from 15 dynamic differential pressure transducers, 4 dynamic pressure transducers, 4 strain gages, and 1 split film anemometer.

The split film anemometer probe was mounted on a traversing mechanism. The anemometer outputs were recorded on tape for later dynamic analysis. The steady state anemometry outputs, consisting of root mean square turbulence, mean angle, mean velocity, and probe temperature,were recorded on the Wind Tunnel Astrodata System. Probe temperature. probe position (2), root mean square differential pressure (6), and filtered strain gage measurements (4) were also recorded on the Astrodata System.

Extensive data analysis from tape playback was conducted after the test. This analysis included root mean square measurements, power spectral densities, auto and cross correlations, and time histories. Reference 8 describes the results of this analysis.

DISCUSSION OF RESULTS

A summary of the 747 vertical tail RMS differential pressure coefficients (RMS differential pressures divided by q) for the transducer pair located at 43 percent span and 25 percent chord ($\overline{V}_{4-11}$) is given in Figure 4. A summary of the 747 vertical tail RMS bending moments at 3.3 percent span is given in Figure 5. Drawing conclusions based on the RMS bending moment data is potentially misleading since resultant levels are amplified at the structural resonant frequencies of the model (which are different from the full scale airplane). However, the trends with various buffet fixes incorporated appear to be similar to the RMS differential pressure coefficient data. The appropriate way to determine the tail bending moments on the airplane (including actual structural responses) using the CS4/CS5 test data is to use the buffet pressures as an input forcing function in the buffet loads computer program which calculates the airplane response and loads. Figure 6 presents a summary of 747 horizontal tail RMS differential pressure coefficients for the transducer pair located at 29 percent span and 25 percent chord ($\overline{HT}_{3-8}$). A summary of 747 horizontal tail RMS bending moments at 13 percent span is given in Figure 7. As noted previously, drawing conclusions based on the RMS bending moment data is potentially misleading since the resultant levels are amplified at the structural resonant frequencies of the model. Figure 8 presents a summary of the 747 tip fin RMS differential pressure coefficients for the transducer pair located at 70 percent span and 25 percent chord ($\overline{TF}_{1-3}$). Evaluation of the orbiter wake characteristics

showed that:

(1) An orbiter wing vortex travels up the 747 CAM tip fin with increasing angle of attack. The vortex center is located vertically near the horizontal stabilizer tip fin junction level at $\alpha_W = -3.3^\circ$ and near to the top of the tip fin at $\alpha_W = +7.5^\circ$.

(2) The 747 horizontal stabilizer at spanwise location $\eta_H = 0.64$ passes through the orbiter wind wake, with transverse turbulence levels of 7.5% of freestream velocity or greater at $\alpha_W = 2^\circ$ through 6°.

(3) The orbiter wake in the vicinity of the 747 vertical fin station is non-isotropic, showing large differences in turbulence level characteristics between the various components.

The 747 vertical tail buffet results consist of RMS differential pressure coefficients, differential pressure PSDs, and differential pressure cross correlation coefficients at zero time lag. The effects of orbiter body flap angle, angle of attack, sideslip angle, scoop height, Mach number, and orbiter elevon angle are included. Results of the CS4 and CS5 tests are presented in Reference 8. Figure 9 shows a comparison of V_{4-11}/q for the CS4 and CS5 tests. Both sets of data are corrected for electrical noise. The CS5 data are also corrected for tunnel noise, but the CS4 data are not. The tunnel noise correction is

less than 1%. The data recorded for the 747-100 configuration are defined as tunnel noise. Figure 10 shows data repeatability for the test. The data are from continuous Mach number sweeps which are run to search for sudden changes in buffet loads and hence are not corrected for either electrical or tunnel noise. These corrections are larger at low Mach numbers and would flatten the curves from M = 0.15 to 0.3. The scatter of discrete data points from the Mach sweeps are averaged to produce the single curves shown. Since the nominal scoops were completely dismantled and reassembled between runs 10 and 133, differences may be because they were not reassembled exactly as they were. The method of positioning the scoops relies on several difficult hand measurements and is not very accurate.

Figure 11 shows a comparison of $\overline{\overline{HT}}_{3-8}/q$ for the CS4 and CS5 tests. The CS5 data are corrected for tunnel noise, but the CS4 data are not, as discussed above. Figure 12 shows $\overline{\overline{HT}}_{3-8}/q$ for three orbiter body flap positions for the tailcone off configuration.

Angle of attack sweeps were made with the anemometer at four tip fin leading edge locations (Model station 82) as shown in Figure 2i. The sweeps were made to investigate the wake flow field of the orbiter wing at the 747 CAM tip fins. Upflow and crossflow (model body axis data) are shown in Figure 13 plotted vs. angle of attack. These data show the effects of the orbiter wing vortex in the vicinity of the tip fin in the upper three tip fin spanwise locations. The data do not show the probe

passing through the vortex center, but the turbulence levels shown in Figure 14 indicate the center was close enough to pick up some of the turbulence from the viscous core. The turbulence peaks in Figure 14 can be used to estimate the angles of attack for closest approach of the core at the three upper tip fin locations. Figure 15 shows velocity levels that were measured. All of the data shown in the tip fin surveys is at M = .3. Runs were made at other Mach numbers (M = .5 and .7), but it was discovered early in the surveys that probe deflections at M = .7 were excessive and testing at this Mach number was terminated. The M = .3 data are considered representative and consistent with the M = .5 data (not shown).

The angle of attack sweep at the horizontal tail spanwise location, $\eta_H = .64$, showed a wake crossing the stabilizer at $\alpha_W = 5^o$ as shown in Figure 16. The wake had turbulence levels on the order of 7.5% or greater from $\alpha_W = 2^o$ to 6^o. The flow angle data showed no rapid upflow or outflow changes with angle of attack as was seen in the tip fin surveys.

Mapping of the Orbiter bluff base flow at M = .3 in the vicinity of the 747 vertical stabilizer (Model station 76.5) was accomplished at fixed model angle of attack ($\alpha_B = 6^o$). Test time did not allow further exploration at other Mach numbers. The probe followed a path as shown in Figure 2i. Comparisons of the longitudinal and transverse components of turbulence at the 747 vertical stabilizer are shown in Figure 17. Off

centerline orbiter base flow characteristics are shown in Figures 18, 19 and 20. The flow variables are plotted against a probe coordinate arc length parameter (arc length to 747 vertical stabilizer height) for convenience.

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TABLE I.

TEST : CS4 & CS5		DATE :

TEST CONDITIONS

MACH NUMBER	REYNOLDS NUMBER (million per foot)	DYNAMIC PRESSURE (pounds/sq. ft.)	STAGNATION TEMPERATURE (degrees Fahrenheit)
0.15	0.98	32.8	106
0.30	1.75	126.0	130
0.325	1.87	163.7	128
0.35	2.00	183.8	131
0.375	2.12	203.9	133
0.40	2.25	224.1	136
0.45	2.50	264.3	142
0.50	2.75	312.1	145
0.55	2.94	369.8	146
0.60	3.125	418.2	147
0.70	3.575	523.3	148

BALANCE UTILIZED: NONE

	CAPACITY:	ACCURACY:	COEFFICIENT TOLERANCE:
NF			
SF			
AF			
PM			
RM			
YM			

COMMENTS:

TABLE II. TEST PROGRAM

TEST: CS4

CONFIGURATION	α	β	δ_{FRL}	ORBITER i_o	ORBITER δ_{BF}	ORBITER δ_e	AIR SCOOP i_{SC}	AIR SCOOP ϕ_{SC}	AIR SCOOP δ_{SC}	MACH NO. 0.15	0.3	0.4	0.5	0.6	0.7
747	▷1	0	0	--	--	--	--	--	--	6			11		
↓	▷2			↓	↓	↓				9	10				
MATED W/$TC_{19.1}$	▷1			5.89	-11.7	0							20		
	▷2				0						21				
	▷1	↓											22		
		+2											23		
↓	↓	+4											25		
MATED	▷1 ▷2	0			↓					32	31	30	29	28	27
	▷1				-5								33		
↓					-11.7								34		
MATED W/$TC_{19.2}$		↓								37			38		39
↓		+4					↓	↓	↓				41		
MATED W/SC_1		0			↓		29	10	1.47				43		
					-5								45		
					0								47		
					5				↓				49		
					-11.7				1.02	52			51		
↓	↓	↓	↓	↓	↓	↓	↓	↓	1.47	58	57	56		55	54

▷1 : α = -6° to 14° by 4° increments

▷2 : α = ▷1 + 16°, 17°, 18°

▷3 α = -6° to 14° by 1° increments

TABLE II. TEST PROGRAM (Continued)

TEST: CS4

CONFIGURATION	α	β	δ_{FRL}	PROBE	i_o	δ_{BF}	δ_e	i_{SC}	ϕ_{SC}	δ_{SC}	MACH NO. 0.15	0.3	0.4	0.5	0.6	0.7
MATED W/SC_1	▷1	+4	0	--	5.98	-11.7	0	29	10	1.47				60		
		+2												62		
		+6												64		
		0					-5							66		
							5							67	68	
747 W/CAM					--	--	--	--	--	--	72	71		70		
MATED W/SC_1 &	▷3			V_1	5.98	-11.7	0	29	10	1.47		81/97/		82/99		83
PROBE												98				
				V_2								86/91		85/90		
				V_3								88/112		89/113		
				V_4								92		93		
				V_5								96		94		
				V_6								95				
				H_1								100		101		
				H_2								103		102		
				H_3								108/111		109/110		
				H_4								104		105		
				H_5								107		106		

▷1 : $\alpha = -6^\circ$ to 14° by 4° increments

▷2 : $\alpha =$ ▷1 $+ 16^\circ, 17^\circ, 18^\circ$

▷3 $\alpha = -6^\circ$ to 14° to 14° by 1° increments

See Model Instrumentation section for definition of V_1 through V_6 and H_1 through H_5.

TABLE II. TEST PROGRAM (Continued)

TEST: CS4 $\quad \delta_{FRL} = 0 \quad i_o = 5.98$

CONFIGURATION	α	β	PROBE ORIENT.	PROBE ROLL	PROBE TRAV.	PROBE STATION	ORBITER δ_{BF}	ORBITER δ_e	AIR SCOOP i_{SC}	AIR SCOOP ϕ_{SC}	AIR SCOOP δ_{SC}	MACH NO. 0.15	0.3	0.4	0.5	0.6	0.7
MATED W/SC1, & PROBE	3	0	VERT.	0	3.2 to 12.2	76.5	-11.7	0	29	10	1.47		115				
				0 to 23.4	12.2								116				
				23.4	12.2 to 10.4								117				
				23.4 to 0	10.4								118				
				0	10.4 to 8.6								119				
				0 to 35.1	8.6								120				
				35.1	8.6 to 6.8								121				
				35.1 to 0	6.8								122				
				0	6.8 to 5.0								123				
				0 to 46.8	5.0								124				
				0	6.8								125				
			HORIZ.	0	3.2 to 12.2								126				
				0 to 23.4	12.2								127				
				23.4	12.2 to 10.4								128				
				23.4 to 0	10.4								129				
				0	10.4 to 8.6								130				

1 : $\alpha = -6^\circ$ to 14° by 4° increments

2 : $\alpha = 1 \quad + 16^\circ, 17^\circ, 18^\circ$

3 $\alpha = -6^\circ$ to 14° to 14° by 1° increments

TABLE II. TEST PROGRAM (Concluded)

TEST: CS5 $\delta_{FRL} = 0$ $i_o = 5.98$ $\phi_{SC} = 10$

CONFIGURATION	α	β	δ_{BF}	δ_e	R_{SC}/i_{SC}	MACH NO. SWEEP	0.15	0.30	0.325	0.35	0.375	0.40	0.45	0.50	0.55	0.6	0.7
MATED W/SC_1	2	0	-11.7	0	--		32	29	28	25	24	21	20	17	16	13	11
	6					10	31	30	27	26	23	22	19	18	15	14	12
						37								33/34			35/36
MATED	2		0				59	56		54	53	50	49	46	45	42	41
	6					38	58	57		55	52	51	48	47	44	43	40
MATED W/SC_1	2				49/29		82	79	78	75	74	67	71	66	70	63	62
	6					60	81	80	77	76	73	68	72	65	69	64	61
	2				34/29	--	109	106	104	101	100	97	96	93	92	89	85
	6					83	108	107	103/105	102	99	98	95	94	91	90	84/86
MATED	2		-11.7		--		132	129	128	125	124	121	120	117	116	113	112
	6					110	131	130	127	126	123	122	119	118	115	114	111
MATED W/SC_2	2				44/29		161	158	157	154	153	149	145	142	141	138	137
	6					135	160	159	156	155	152	151	144	143	140	139	136
	6				32/ 28.75	162											
	6				44/ 28.5	163		169				167		166		168	
MATED	6					170		174				173		172		171	
MATED W/SC_2	6				44/29	175											
	0	2				176											
	6					177											
MATED	2	0			--		190	187				186		183		182	179
	6					178	189	188				185		184		181	180
747	2		--	--			204	201				200		197		196	193
	6					192	203	202				199		198		195	194

TABLE III. MODEL DIMENSIONAL DATA

a. Carrier Model

MODEL COMPONENT: ATTACH STRUCTURE - AT_{xx}

GENERAL DESCRIPTION: Orbiter attachment struts

MODEL SCALE: .030

DRAWING NUMBER: 1319-174, 747-MD-680, 747-MD-678

DIMENSIONS:

FWD

i_o	FAIRED	UNFAIRED	HEIGHT OF ACT. TIP JUNCT. FULL SCALE IN.	MODEL SCALE IN.
3	AT_{106}	AT_{101}	147.5	4.426
$4\frac{1}{4}$	AT_{107}	AT_{102}	167.7	5.032
6	AT_{108}	AT_{103}	195.9	5.878
8	AT_{109}	AT_{104}	228.0	6.843

AFT

i_o	FAIRED	UNFAIRED		
All	AT_{110}	AT_{105}	--	--

TABLE IIIa. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: $B_{27.8}$

GENERAL DESCRIPTION: Body, 747 project with Auxiliary Power Vent exit

MODEL SCALE: 0.03

DRAWING NUMBER: 65-69716

DIMENSIONS:	FULL SCALE	MODEL SCALE
Length, in.	2702	81.09
Max. Width, in.	--	7.66
Max. Depth		
Fineness Ratio		
Area		
Max. Cross-Sectional		
Planform		
Wetted, ft^2	14122	12.71
Base		

TABLE IIIa. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: HORIZONTAL TAIL - $H_{15.1}$

GENERAL DESCRIPTION: Swept Horizontal Tail with planform radius fillet at L.E. - Body intersection

MODEL SCALE: 0.03

DRAWING NUMBER: 65-66630, 69-49180, 1007-477

DIMENSIONS:	FULL SCALE	MODEL SCALE
EXPOSED DATA (one side)		
Area - ft^2	736.11	0.6625
Span - in.	433.25	12.997
Aspect Ratio		
Taper Ratio		
Dihedral Angle-deg.	7	7
Incidence Angle-deg.		
Sweep Back Angle-deg. L. E.	43.08	43.08
Chords-in.		
Root	388	11.64
Tip	97	2.91
MAC		
.25 MAC Location-in.		
Fuselage station	2564	76.920

TABLE IIIa. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: HORIZONTAL TAIL $H_{15.6}$

GENERAL DESCRIPTION: Horizontal tail $H_{15.1}$ with vertical fins on each tip at body B.L. 12.82

MODEL SCALE: 0.03

DRAWING NUMBER: 1319-60

DIMENSIONS: (TIP FIN)	FULL SCALE	MODEL SCALE
(See $H_{15.1}$ for Horiz. Tail Details)		
Exposed Data (one side)		
Area - ft^2	200	0.130
Span - in.	251.44	7.543
Aspect Ratio	2.19	2.19
Taper Ratio	1.00	1.00
Dihedral Angle-deg.	0	--
Incidence Angle-deg.	--	--
Sweep Back Angle-deg.	0	0
Chords - in.	114.54	3.43

TABLE IIIa. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: M_{25}

GENERAL DESCRIPTION: Inboard 747, J_{T9D} Nacelle strut

MODEL SCALE: 0.03

DRAWING NUMBER:

DIMENSIONS:	FULL SCALE	MODEL SCALE
Wing B.L. of nacelle ℄, in.	470.0	14.100
Cant angle, deg. inboard (toe in at LE Int)	2	2

TABLE IIIa. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: $M_{26.8}$

GENERAL DESCRIPTION: Outboard 747, J_{T9D} Nacelle Strut

MODEL SCALE: 0.03

DRAWING NUMBER: 937-590

DIMENSIONS:	FULL SCALE	MODEL SCALE
Wing, B.L. of nacelle & in.	834.0	25.02
Cant angle, deg. inboard (toe in at LE Int.)	2	2

TABLE IIIa. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: N_{57}

GENERAL DESCRIPTION: Inboard Fan Cowl and Primary 747 Nacelle, flow through type

MODEL SCALE: 0.03

DRAWING NUMBER: 5.0 1007-96, 97

DIMENSIONS:	FULL SCALE	MODEL SCALE
Length, in.	103.2	3.096
Max. Width, in.	214.8	8.592
Max. Depth, in.	102.0	3.060

TABLE IIIa. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: N_{58}

GENERAL DESCRIPTION: Outboard Fan Cowl and Primary 747 Nacelle, flow through type

MODEL SCALE: 0.03

DRAWING NUMBER: 5.0. 1007-96, -97

DIMENSIONS:	FULL SCALE	MODEL SCALE
Length, in.	103.2	3.096
Max. Width, in.	214.8	8.592
Max. Depth, in.	102.0	3.060

TABLE IIIa. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: T_{19}

GENERAL DESCRIPTION: Flap track fairings, 4 on each side.

MODEL SCALE: 0.03

DRAWING NUMBER: 5.0. 1007-403

DIMENSIONS:	FULL SCALE	MODEL SCALE
WBL of Track no. 1, in.	235.3	7.06
WBL of Track no. 2, in.	353	10.59
WBL of Track no. 3, in.	652	17.56
WBL of Track no. 4, in.	743.6	22.31
Distance from wing trailing edge to track trailing edge, in.	50	1.5

TABLE IIIa. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: $V_{9.1}$

GENERAL DESCRIPTION: Swept Vertical Tail

MODEL SCALE: 0.03

DRAWING NUMBER: 65-6 9716; 1007-26, -610; 937-319

DIMENSIONS:	FULL SCALE	MODEL SCALE
TOTAL DATA		
Area (Theo)-Ft^2	830	.7470
Planform		
Span (Theo) - In.	386.5	11.595
Aspect Ratio		
Rate of Taper		
Taper Ratio		
Sweep-Back Angles, Degrees		
Leading Edge	50.12	50.12
Trailing Edge		
0.25 Element Line		
Chords:		
Root (Theo) WP-in.	461.67	13.85
Tip (Theo) WP-in.	157	4.71
MAC		
Fus. Sta. of .25 MAC	2529.6	75.888

TABLE IIIa. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: WING - $W_{44.1}$

GENERAL DESCRIPTION: Swept 747 Wing

MODEL SCALE: 0.03

DRAWING NUMBER: 65-89585

DIMENSIONS:	FULL SCALE	MODEL SCALE
TOTAL		
Area (Theo.) Ft^2		
Planform	5500	4.95
Span (Theo. In.)	2348	70.44
Aspect Ratio	6.96	6.96
Rate of Taper		
Taper Ratio		
Dihedral Angle, degrees	7	7
Incidence Angle, degrees		
Aerodynamic Twist, degrees		
Sweept Back Angles, degrees		
Leading Edge		
Trailing Edge		
0.25 Element Line		
Chords:		
MAC	327.8	9.834
Fus. Sta. of .25 MAC	1339.87	40.196
W.P. of .25 MAC	190.42	5.7225
B.L. of .25 MAC		

TABLE IIIa. MODEL DIMENSIONAL DATA (Concluded)

MODEL COMPONENT: WING-BODY FAIRING, $X_{18.4}$

GENERAL DESCRIPTION: Basic 747 wing-body fairing that includes the housing for the body landing gear. The fairing is an integral part of the body skins.

MODEL SCALE: 0.030

DRAWING NUMBER: 65C13695

TABLE III. MODEL DIMENSIONAL DATA

b. Orbiter Model

MODEL COMPONENT: BODY - B_{26}

GENERAL DESCRIPTION: Configuration 140A/B orbiter fuselage

NOTE: B_{26} is identical to B_{24} except underside of fuselage has been refaired to accept W_{116}.

MODEL SCALE: 0.030

DRAWING NUMBER: VL70-000143B -000200, -000205, -006089, -000145, -000140A, -000140B

DIMENSIONS:

	FULL SCALE	MODEL SCALE
Length (OML: Fwd Sta. X_o = 235) In.	1293.3	38.799
Length (IML: Fwd Sta. X_o = 238) In.	1290.3	38.709
Max Width (@ X_o = 1528.3) In.	264.00	7.920
Max Depth (@ X_o = 1464) In.	250.00	7.500
Fineness Ratio	0.264	0.264
Area - Ft^2		
Max. Cross-Sectional	340.88	0.3068

TABLE IIIb. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: CANOPY - C_9

GENERAL DESCRIPTION: Configuration 3A. Canopy used with fuselage B_{26}.

MODEL SCALE: 0.030 MODEL DRAWING: SS-A00147, Release 12

DRAWING NUMBER: VL70-000143A

DIMENSIONS:	FULL SCALE	MODEL SCALE
Length (X_o = 434.643 to 578), In.	143.357	4.301
Max Width (@ X_o = 513.127), In.	152.412	4.572
Max Depth (@ X_o = 485.0), In.	25.00	0.750

TABLE IIIb. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: SLOTTED ELEVON (6-INCH GAP) - E_{43}

GENERAL DESCRIPTION: Configuration 140A/B orbiter elevon.

NOTE: E_{43} is a slotted version of E_{26}. Data are for one side.

MODEL SCALE: 0.030

DRAWING NUMBER: VL70-000200, -006089, -006092

DIMENSIONS:	FULL SCALE	MODEL SCALE
Area - Ft^2	210.0	0.189
Span (equivalent), In.	349.2	10.476
Inb'd equivalent chord, In.	118.004	3.540
Outb'd equivalent chord, In.	55.192	1.656
Ratio movable surface chord/ total surface chord		
At Inb'd equiv. chord	0.2096	0.2096
At Outb'd equiv. chord	0.4004	0.4004
Sweep Back Angles, degrees		
Leading Edge	0.00	0.00
Trailing Edge	- 10.056	- 10.056
Hingeline	0.00	0.00
Area Moment (Product of area and $\bar{c}$), Ft^3	1587.25	0.043
Mean Aerodynamic Chord, In.	90.7	2.721

TABLE IIIb. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: BODY FLAP - F_8

GENERAL DESCRIPTION: Configuration 140A/B orbiter body flap. Hingeline located at $X_o = 1528.3$. $Z_o = 284.3$

MODEL SCALE: 0.030 MODEL DRAWING: SS-A00147, Release 12

DRAWING NUMBER: VL70-000140A, -000145

DIMENSIONS:	FULL SCALE	MODEL SCALE
Length (X_o = 1520 to X_o = 1613), In.	93.00	2.79
Max Width (In.)	262.0	7.86
Max Depth (@ X_o = 1520), In.	23.00	0.69
Fineness Ratio		
Area - Ft^2		
Max. Cross-Sectional		
Planform	150.525	0.406
Wetted		
Base	41.847	0.113

TABLE IIIb. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: OMS POD - M_{16}

GENERAL DESCRIPTION: Configuration 140C orbiter OMS pod - short pod.

MODEL SCALE: 0.030

DRAWING NUMBER: VL70-008401, -008410

DIMENSIONS:	FULL SCALE	MODEL SCALE
Length (OMS Fwd Sta. X_o = 1310.5), In.	258.50	7.755
Max Width (@ X_o = 1511), In.	136.8	4.104
Max Depth (@ X_o = 1511), In.	74.70	2.241
Fineness Ratio	2.484	2.484
Area - Ft^2		
Max. Cross-Sectional	58.864	0.053

TABLE IIIb. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: MPS NOZZLES - N_{24}

GENERAL DESCRIPTION: Configuration 140A/B orbiter MPS nozzles

MODEL SCALE: 0.030 MODEL DRAWING: SS-A00147, Release 12

DRAWING NUMBER: VL70-00503A, -000140A

DIMENSIONS:	FULL SCALE	MODEL SCALE
MACH NO.		
Length - In.		
Gimbal Point to Exit Plane	157.0	4.71
Throat to Exit Plane	99.2	2.976
Diameter - In.		
Exit	91.000	2.73
Throat		
Inlet		
Area - ft^2		
Exit	45.166	0.0407
Throat		
Gimbal Point (station) - In.		
Upper Nozzle		
X	1445.00	43.35
Y	0.0	0.0
Z	443.00	13.29
Lower Nozzle		
X	1468.170	44.045
Y	±53.000	±1.59
Z	342.640	10.279
Null Position - Deg.		
Upper Nozzle		
Pitch	16	16
Yaw	0	0
Lower Nozzle		
Pitch	10	10
Yaw	3.5	3.5

TABLE IIIb. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: OMS NOZZLES - N_{28}

GENERAL DESCRIPTION: Configuration 140A/B orbiter OMS nozzles

MODEL SCALE: 0.030

DRAWING NUMBER: VL70-000140A (Location), SS-A00106, Release 5 (Contour)

DIMENSIONS:	FULL SCALE	MODEL SCALE
MACH NO.		
Length - In.		
Gimbal Point to Exit Plane		
Throat to Exit Plane		
Diameter - In.		
Exit		
Throat		
Inlet		
Area - ft^2		
Max. Cross-Sectional (1 nozzle)		
Throat		
Gimbal Point (Station) - In.		
Left Nozzle		
X_o	1518.0	45.54
Y_o	- 88.0	- 2.64
Z_o	492.0	14.76
Right Nozzle		
X_o	1518.0	45.54
Y_o	88.0	2.64
Z_o	492.0	14.76
Null Position - Deg.		
Left Nozzle		
Pitch	15°49'	15°49'
Yaw	12°17'	12°17'
Right Nozzle		
Pitch	15°49'	15°49'
Yaw	12°17'	12°17'

TABLE IIIb. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: RUDDER - R_5

GENERAL DESCRIPTION: Configuration 140C orbiter rudder (identical to configuration 140A/B rudder)

MODEL SCALE: 0.030

DRAWING NUMBER: VL70-000146B, -000095

DIMENSIONS:	FULL SCALE	MODEL SCALE
Area - Ft^2	100.15	0.090
Span (equivalent), In.	201.00	6.030
Inb'd equivalent chord, In.	91.585	2.748
Outb'd equivalent chord, In.	50.833	1.525
Ratio movable surface chord/ total surface chord		
At Inb'd equiv. chord	0.400	0.400
At Outb'd equiv. chord	0.400	0.400
Sweep Back Angles, degrees		
Leading Edge	34.83	34.83
Trailing Edge	26.25	26.25
Hingeline	34.83	34.83
Area Moment (Product of area & $\bar{c}$), $Ft.^3$	610.92	0.165
Mean Aerodynamic Chord, In.	73.2	2.196

TABLE IIIb. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: SC_1 - AIR SCOOPS

GENERAL DESCRIPTION: Two deflector vanes located above MPS nozzle no. 1. The vanes were simulated by flat plates mounted on a rectangular cross-section support shaft. The shaft was mounted on nozzle no. 1 at its exit plane. Vane deflection angle, shaft length, and shaft cant angle in the roll plane were adjustable during the test.

MODEL SCALE: 0.03

DIMENSIONS:	FULL SCALE	MODEL SCALE
Vane Span, In.	24.67	0.74
Vane Chord, In.	37.00	1.11
Vane Planform Area, Ft^2	6.85	0.006
Vane Thickness, In.	3.17	0.095

TABLE IIIb. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: SC_2 - AIR SCOOPS

GENERAL DESCRIPTION: Same as SC_1 with vane size increased to provide twice the area of SC_1.

MODEL SCALE: 0.03

DIMENSIONS:	FULL SCALE	MODEL SCALE
Vane Span, In.	34.89	1.05
Vane Chord, In.	52.33	1.57
Vane Planform Area, Ft^2	13.70	0.012
Vane Thickness, In.	3.17	0.095

TABLE IIIb. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: TAILCONE, TC_{19}

GENERAL DESCRIPTION: Orbiter base fairing. The fairing is mounted on the base of the orbiter body. TC_{19} is a derivative of TC_4. The changes are primarily in the OMS pod area. TC_{19} is recessed for nesting the body flap while TC_4 was made to simulate the body flap nested. TC_{19} is not vented.

MODEL SCALE: 0.030

MODEL DRAWING NUMBER:

VEHICLE DRAWING NUMBER: BCD V70-30-330-02

DIMENSIONS:	FULL SCALE	MODEL SCALE
Length, In. (T.E. @ X_o = 1900)	459.3	13.779
Max. Width, In. (X_o = 1523)	303	9.090
Max. Height, In. (X_o = 1466)	286	8.59
Area, Ft^2		
Projected Frontal Area Max. Cross-Sectional (X_o = 1523)	504.6	0.454
Wetted	1840.0	1.656

TABLE IIIb. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: TAILCONE, $TC_{19.1}$

GENERAL DESCRIPTION: Orbiter base fairing same as TC_{19} with a 0.711 inch diameter vent on the upper surface of the tailcone at OMS 46.2 and on the lower surface at OMS 55.8. Both vents are located on the orbiter plane of symmetry.

MODEL SCALE: 0.030

MODEL DRAWING NUMBER:

VEHICLE DRAWING NUMBER: BCD V70-30-330-02

DIMENSIONS:	FULL SCALE	MODEL SCALE
Length, In. (T.E. at X_o = 1900)	459.3	13.779
Max. Width, In. (at X_o = 1523)	303.0	9.09
Max. Height, In. (at X_o = 1466)	286.0	8.59
Area, Ft^2		
Projected Frontal Area Max. Cross-Sectional	504.6	0.454
Wetted	1840.0	1.656
Vent area, In^2	441.0	0.397

TABLE IIIb. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: TAILCONE - $TC_{19.2}$

GENERAL DESCRIPTION: Same as TC_{19} except the forward section of tailcone was removed, leaving a "partial" tailcone. The tailcone was parted on a line parallel to the upper MPS nozzle base (16° from vertical) at a distance normal to the nozzle base of 49.35"

TABLE IIIb. MODEL DIMENSIONAL DATA (Continued)

MODEL COMPONENT: VERTICAL - V_8

GENERAL DESCRIPTION: Configuration 140C orbiter vertical tail (identical to configuration 140A/B vertical tail)

MODEL SCALE: 0.030

DRAWING NUMBER: VL70-000140C, -000146B

DIMENSIONS:	FULL SCALE	MODEL SCALE
TOTAL DATA		
Area (Theo) - Ft^2		
Planform	413.243	0.372
Span (Theo) - In.	315.72	9.472
Aspect Ratio	1.675	1.675
Rate of Taper	0.507	0.507
Taper Ratio	0.404	0.404
Sweep-Back Angles, Degrees		
Leading Edge	45.00	45.00
Trailing Edge	26.25	26.25
0.25 Element Line	41.13	41.13
Chords:		
Root (Theo) WP	268.50	8.055
Tip (Theo) WP	108.47	3.254
MAC	199.81	5.994
Fus. Sta. of .25 MAC	1463.35	43.901
W.P. of .25 MAC	635.52	19.066
B.L. of .25 MAC	0.00	0.00
Airfoil Section		
Leading Wedge Angle - Deg.	10.00	10.00
Trailing Wedge Angle - Deg.	14.92	14.92
Leading Edge Radius	2.00	0.060
Void Area	13.17	0.0019
Blanketed Area	0.0	0.0

TABLE IIIb. MODEL DIMENSIONAL DATA (Concluded)

MODEL COMPONENT: WING - W_{116}

GENERAL DESCRIPTION: Configuration 4 NOTE: Identical to W_{114} except airfoil thickness. Dihedral angle is along trailing edge of wing.

MODEL SCALE: 0.030 DRAWING NUMBER: VL70-000140A, -000200

DIMENSIONS:	FULL SCALE	MODEL SCALE
TOTAL DATA		
Area (Theo.) Ft^2		
Planform	2690.00	2.421
Span (Theo.) In.	936.68	28.10
Aspect Ratio	2.265	2.265
Rate of Taper	1.177	1.177
Taper Ratio	0.200	0.200
Dihedral Angle, Degrees	3.500	3.500
Incidence Angle, Degrees	0.500	0.500
Aerodynamic Twist, degrees	3.000	3.000
Sweep Back Angles, Degrees		
Leading Edge	45.000	45.000
Trailing Edge	- 10.056	- 10.056
0.25 Element Line	35.209	35.209
Chords:		
Root (Theo) @ B.P. = zero	689.24	20.677
Tip, (Theo) @ B.P.	137.85	4.136
MAC	474.81	14.244
Fus. Sta. of .25 MAC	1136.83	34.105
W.P. of .25 MAC	290.58	8.717
B.L. Of .25 MAC	182.13	5.464
EXPOSED DATA		
Area (Theo) Ft^2	1751.50	1.576
Span, (Theo) In. BP108	720.68	21.620
Aspect Ratio	2.059	2.059
Taper Ratio	0.245	0.245
Chords		
Root @ B.P. = 108, in.	562.09	16.863
Tip 1.00 b/2	137.85	4.136
MAC	392.83	11.785
Fus. Sta. of .25 MAC	1185.98	35.579
W.P. of .25 MAC	294.30	8.829
B.L. of .25 MAC	251.77	7.553
Airfoil Section (Rockwell Mod NASA)XXXX-64		
Root b/2 =	0.113	0.113
Tip b/2 =	0.120	0.120
Data for (1) of (2) Sides		
Leading Edge Cuff		
Planform Area, Ft^2	113.18	0.102
Leading Edge Intersects Fus M. L. @ Sta	500.00	15.00
Leading Edge Intersects Wing @ Sta	1024.00	30.72

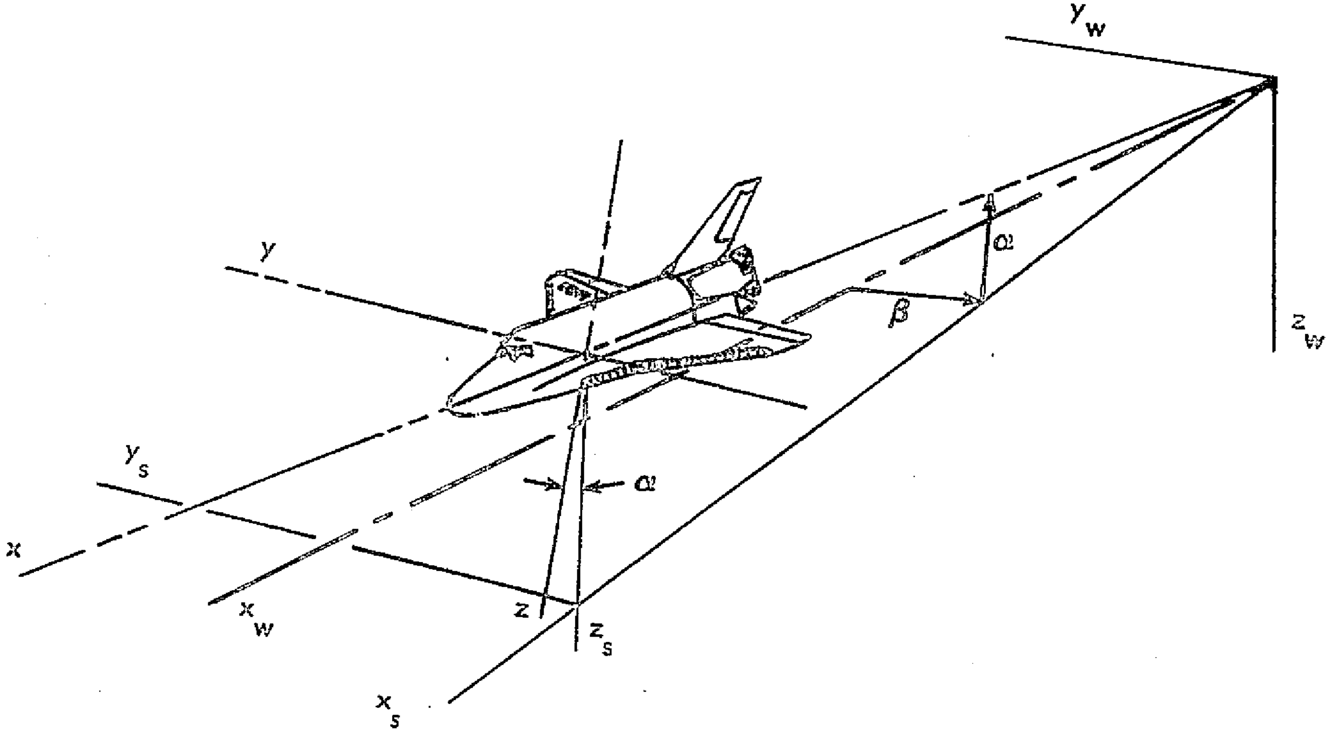
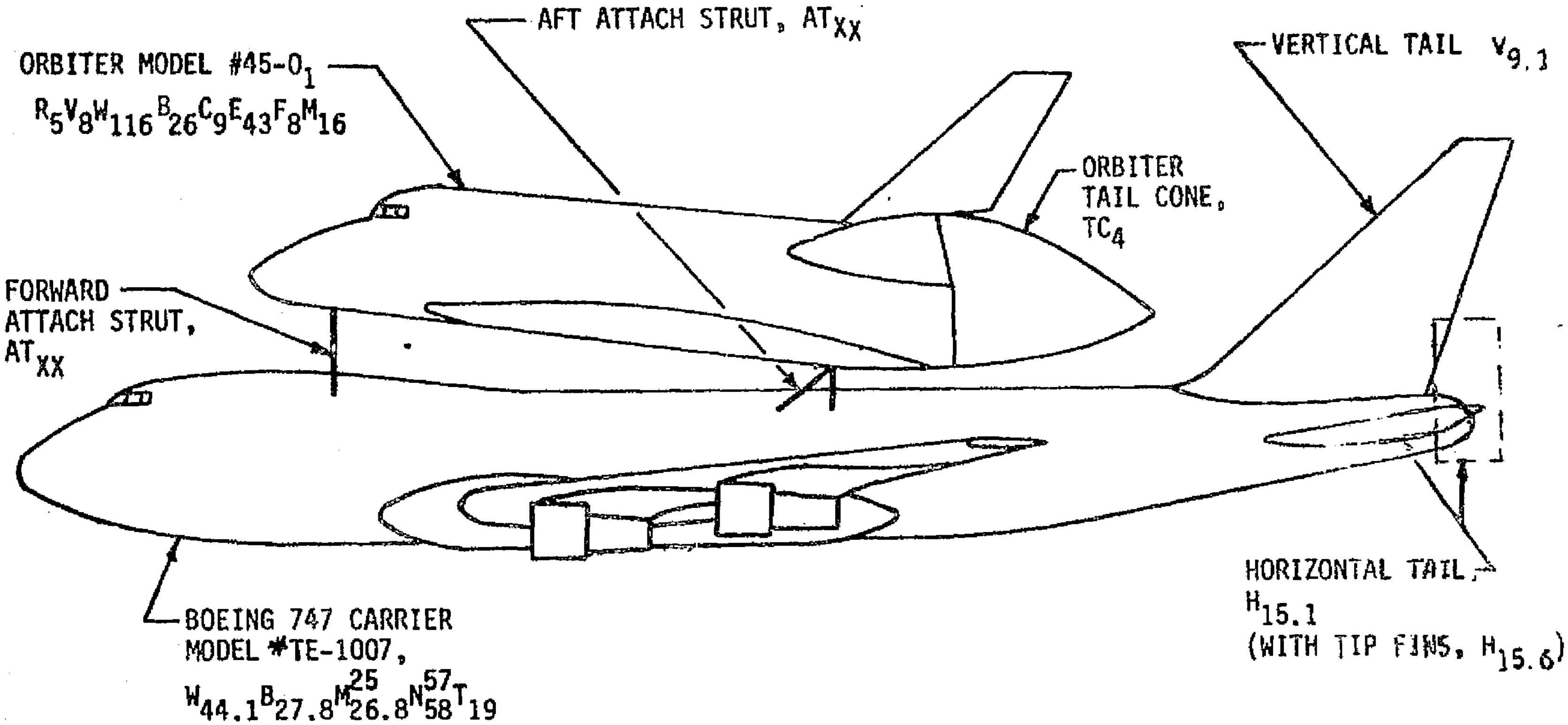
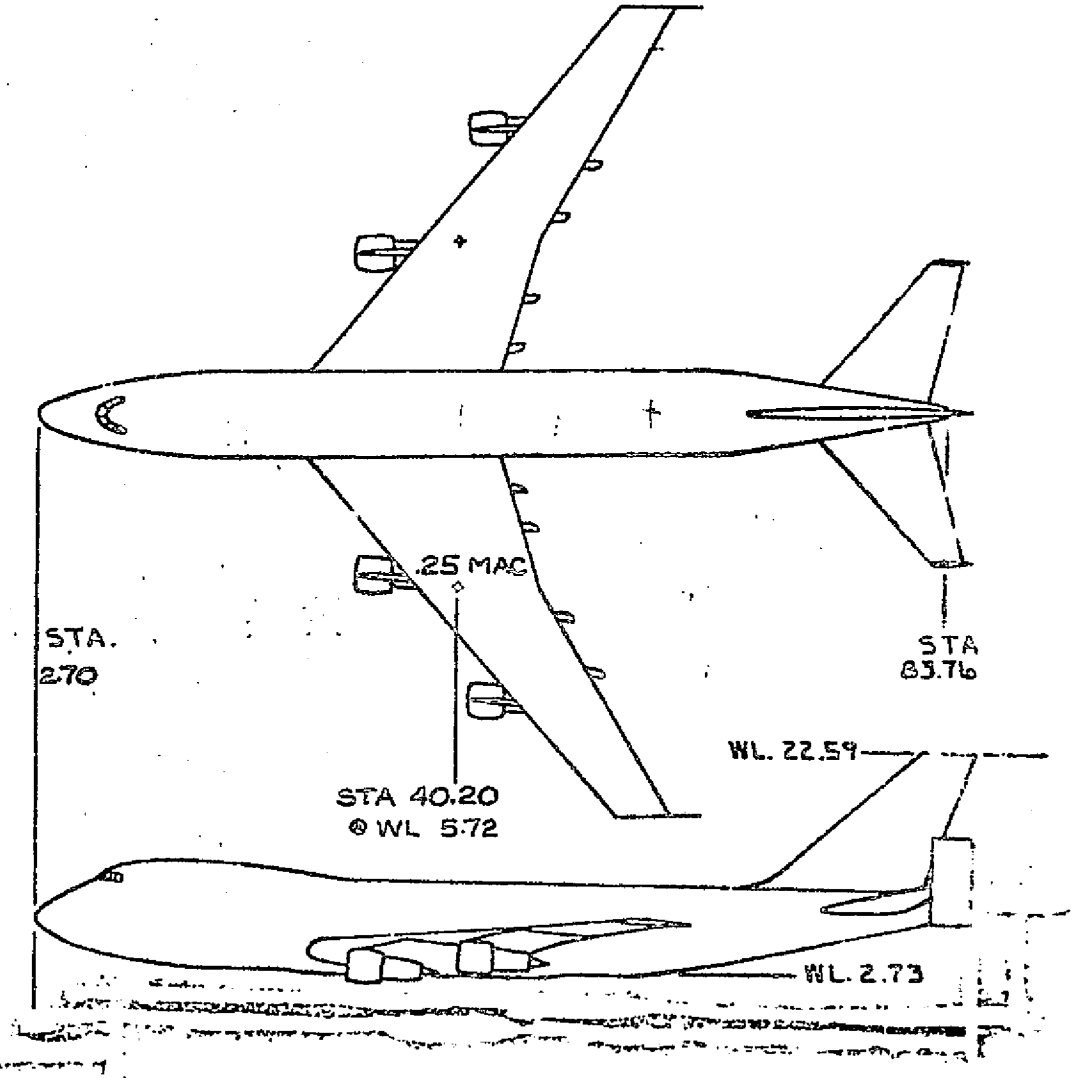
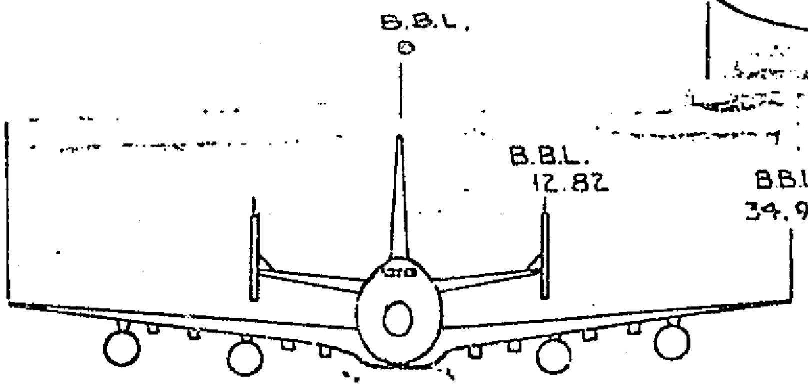


Figure 1. - Axis Systems.



a. Mated Orbiter and Carrier Model Configuration
Figure 2. Model sketches.

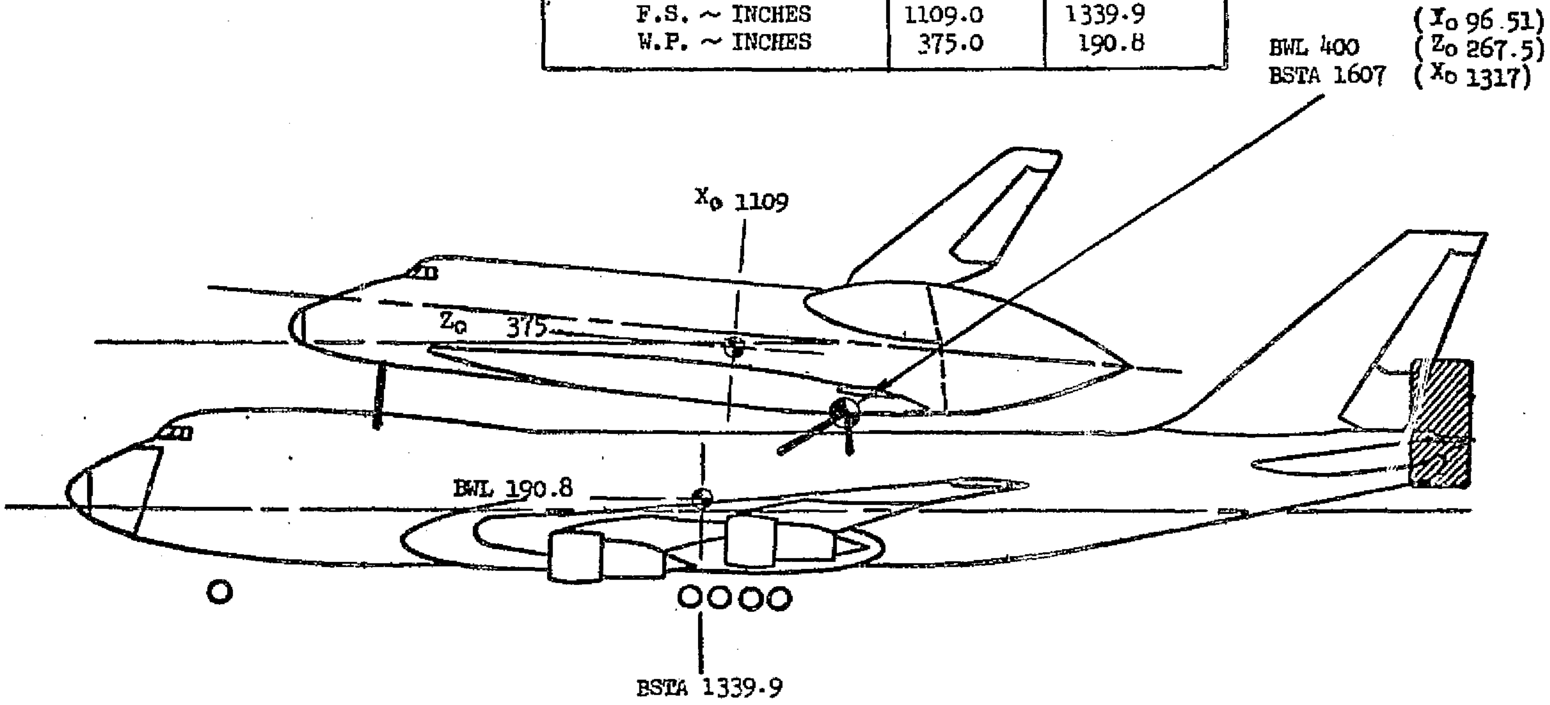




b. 747 Carrier Configuration
Figure 2. Continued.

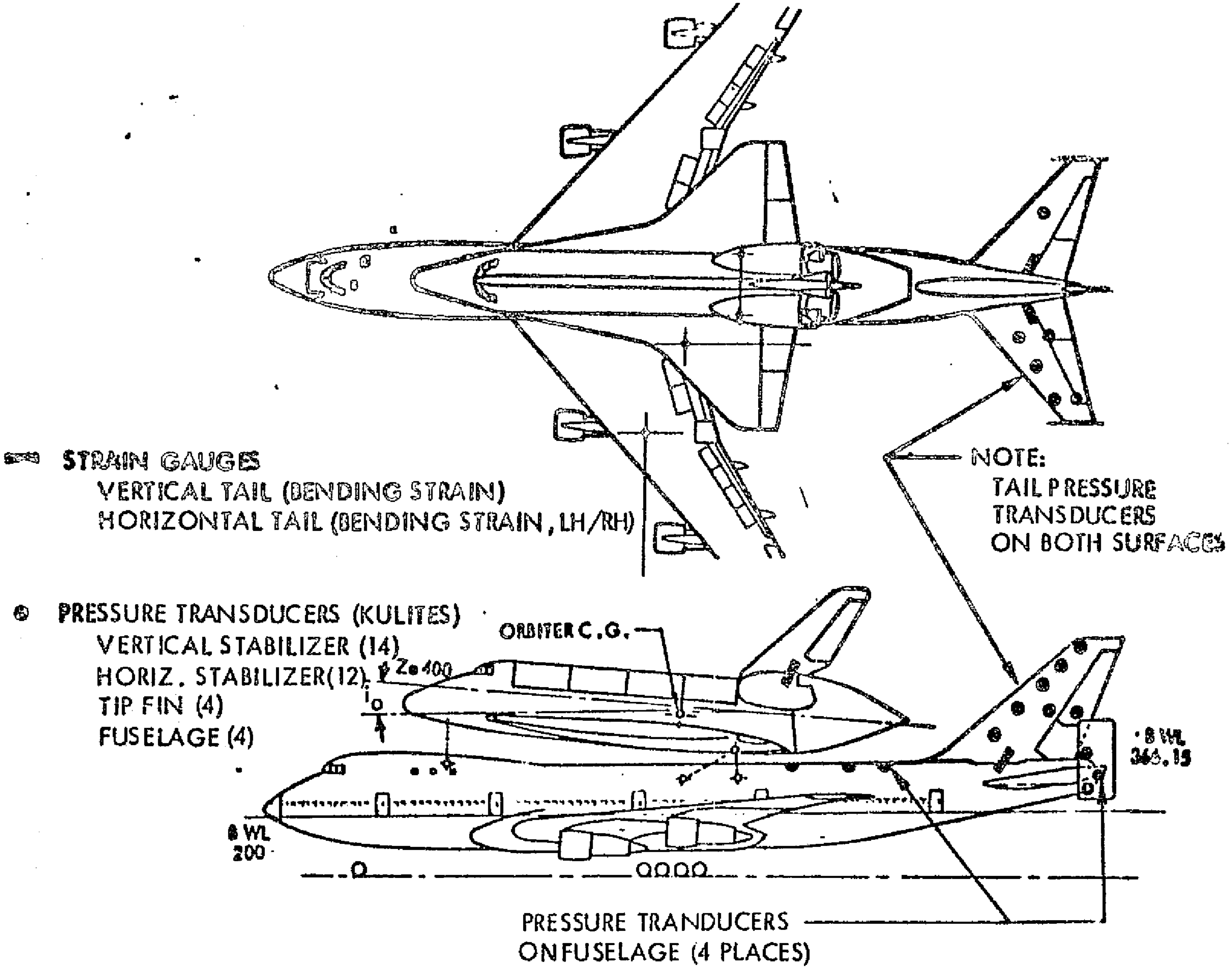
REFERENCE DIMENSIONS (FS)

	ORBITER	747 CARRIER
WING AREA ~ Ft^2	2690	5500
MAC ($\bar{c}$) ~ INCHES	474.81	327.78
SPAN (b) ~ INCHES	936.68	2348.04
MOMENT REFERENCE CENTER	67.5% LB	25.0 % $\bar{C}$
F.S. ~ INCHES W.P. ~ INCHES	1109.0 375.0	1339.9 190.8



c. Orbiter/747 Flight Test Configuration

Figure 1. Continued

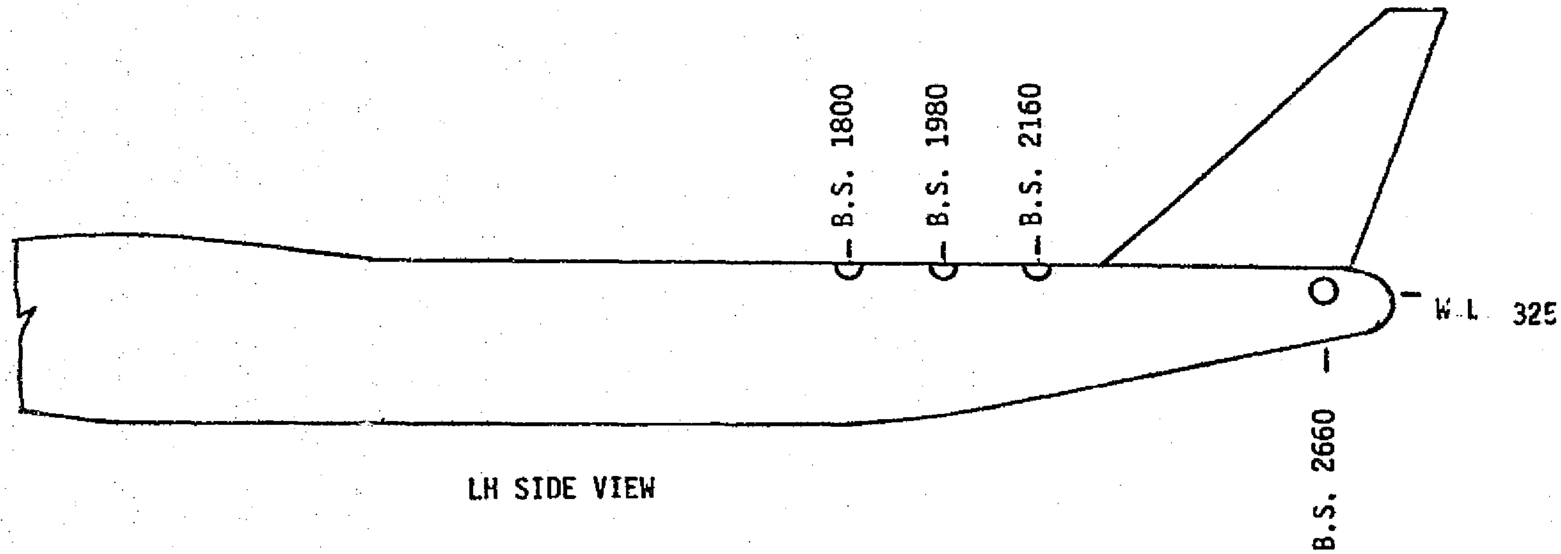


d. Model Instrumentation Summary
Figure 2. Continued.

O KULITE PRESSURE TRANSDUCER LOCATION.

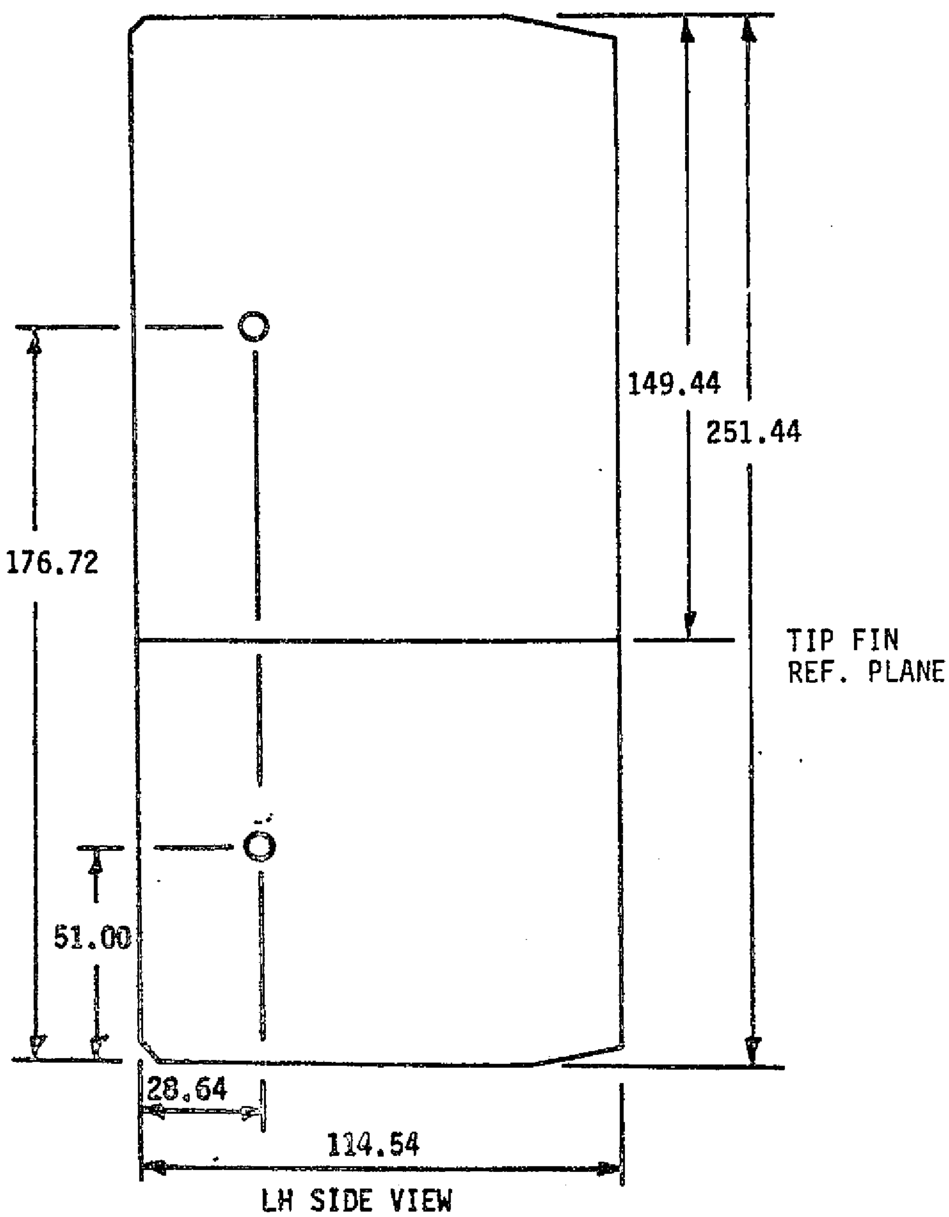
NOTE: 1. ALL STATIONS ARE INCHES, AIRPLANE SCALE.

2. THE TRANSDUCERS ON THE TOP OF THE 747 FUSELAGE SHOULD BE AS CLOSE TO THE AIRPLANE CENTERLINE (B.L.=0) AS EXISTING MODEL CONSTRUCTION ALLOWS.



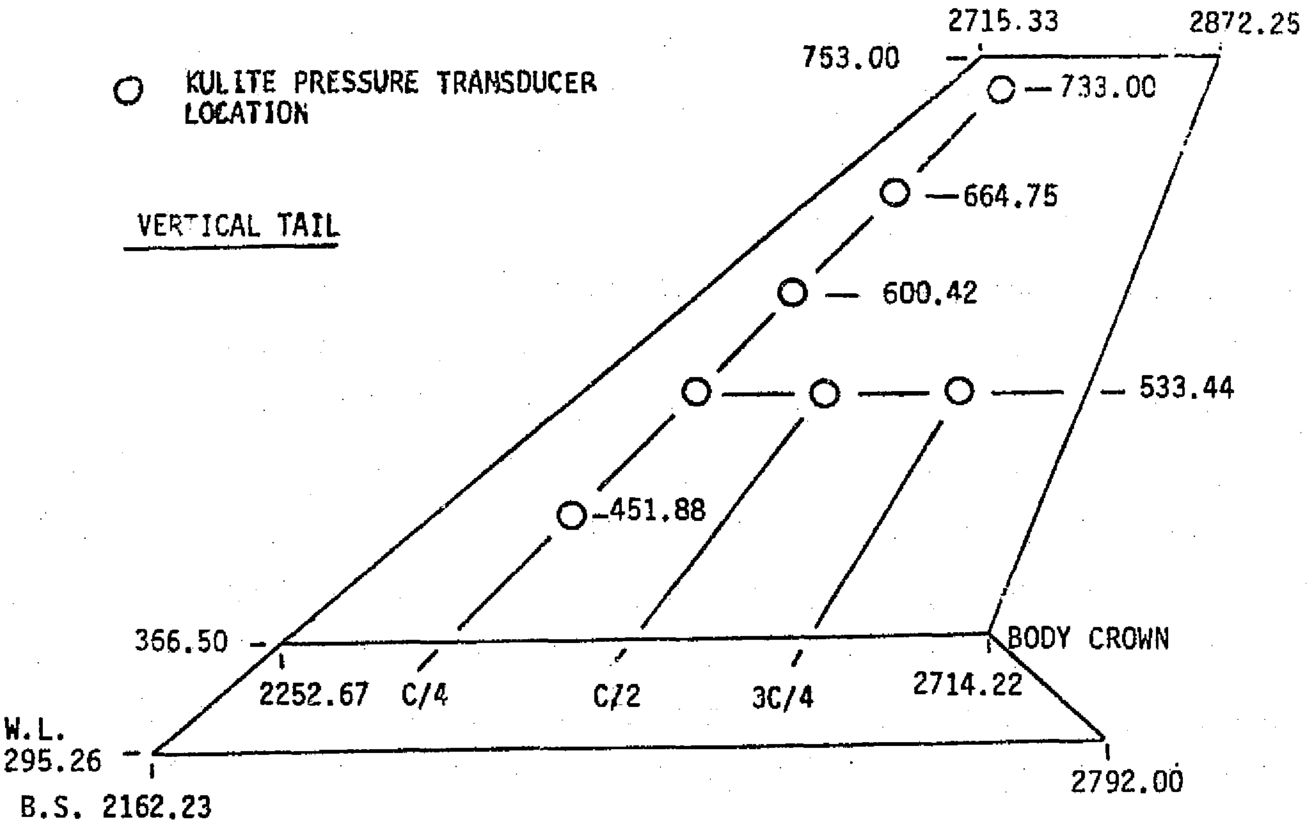
e. 747 CAM Buffet Model Fuselage Instrumentation
Figure 2. Continued.

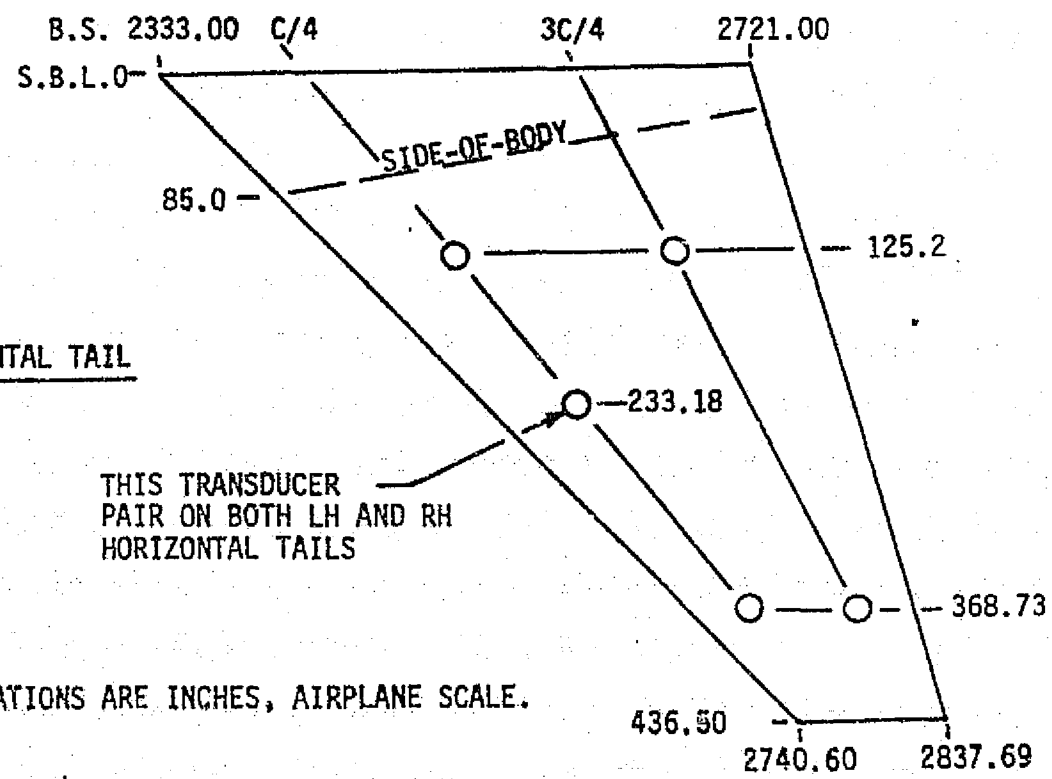
O Kulite pressure transducer location



NOTE: ALL DIMENSIONS ARE INCHES, AIRPLANE SCALE

f. 747 CAM Buffet Model Tip Fin Instrumentation
Figure 2. Continued.

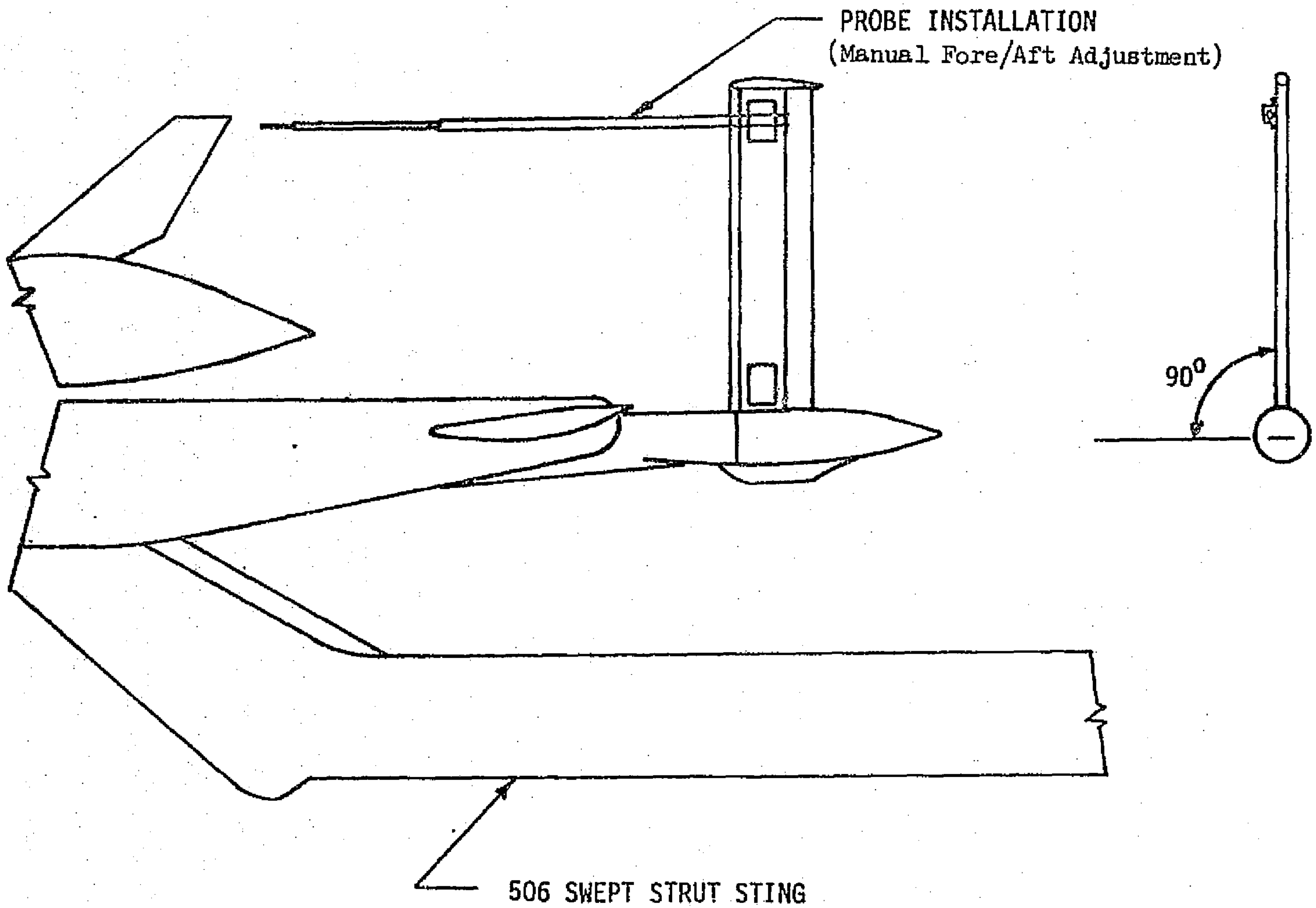




NOTE: ALL STATIONS ARE INCHES, AIRPLANE SCALE.

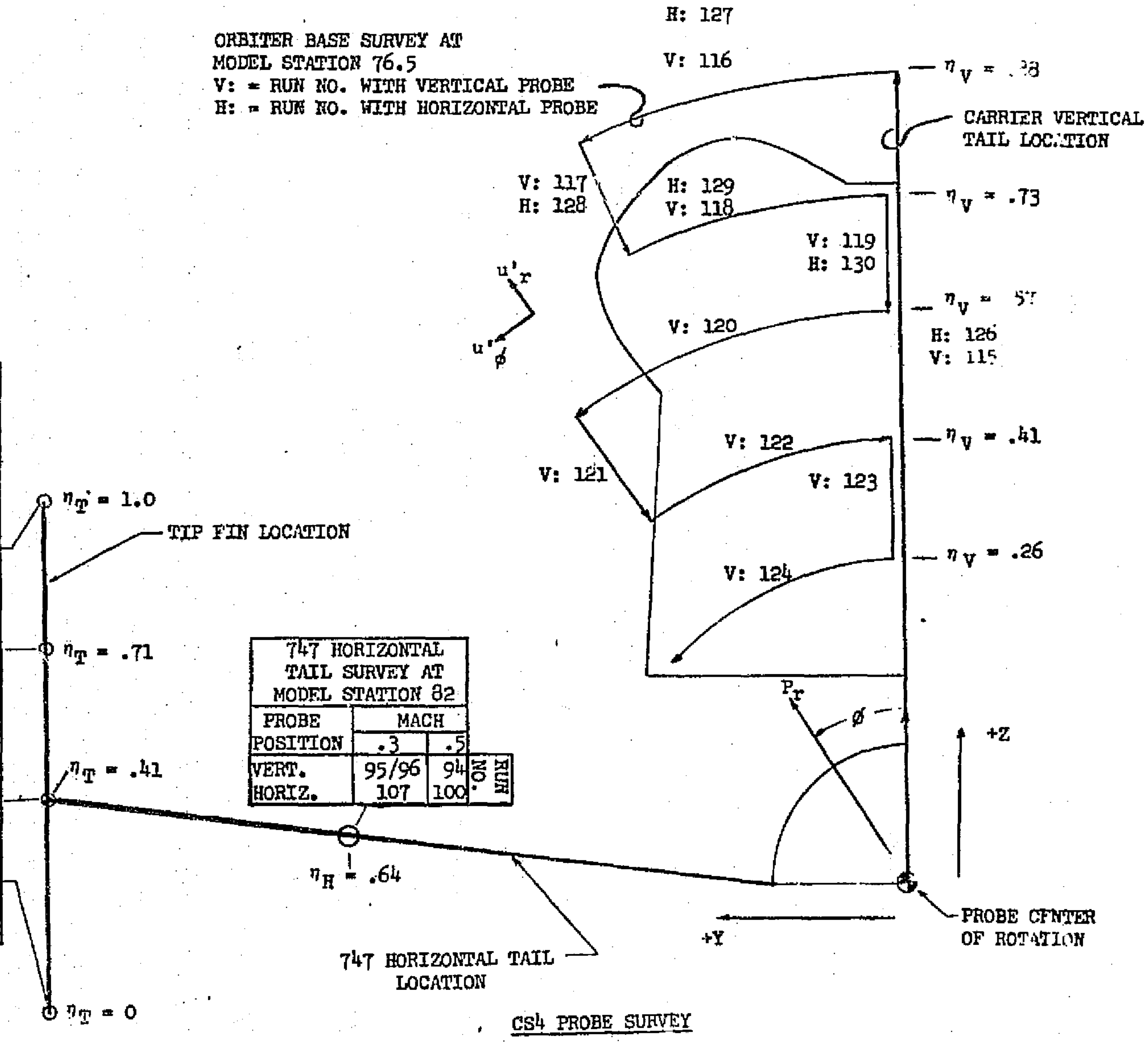
g. 747 CAM Buffet Model Empennage Instrumentation

Figure 2. Continued.



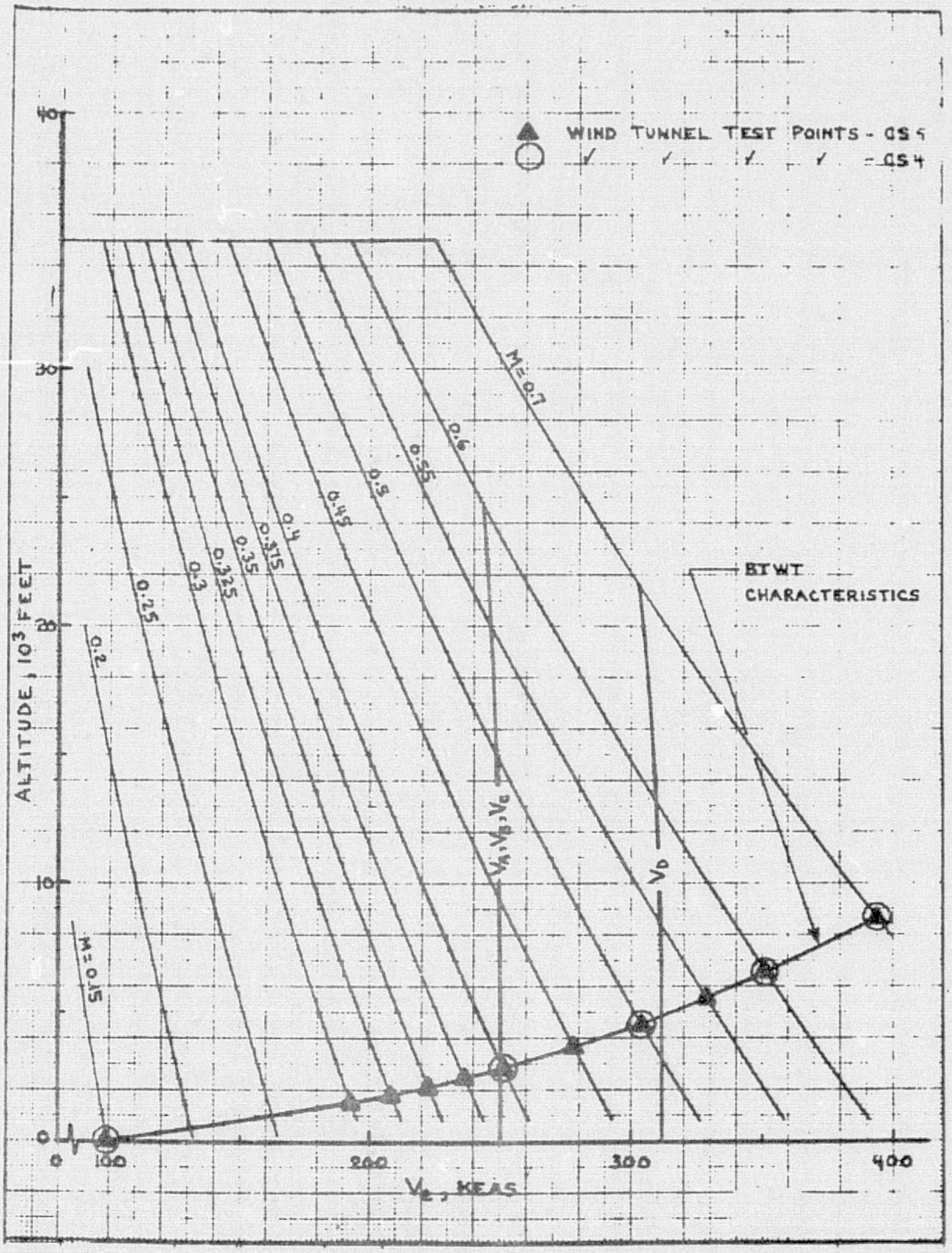
h. Split Film Probe Installation
Figure 2. Continued

RUN NUMBERS FOR 747 TIP FIN SURVEY AT MODEL STATION 82			
PROBE POS.	MACH .3	.5	.7
VER.	81 97 98	82 99	83
HOR.	100	101	
VER.	86 91	85 90	
HOR.	103	102	
VER.	92	93	
HOR.	104	105	
VER.	88 112	89 113	
HOR.	108 111	109 110	

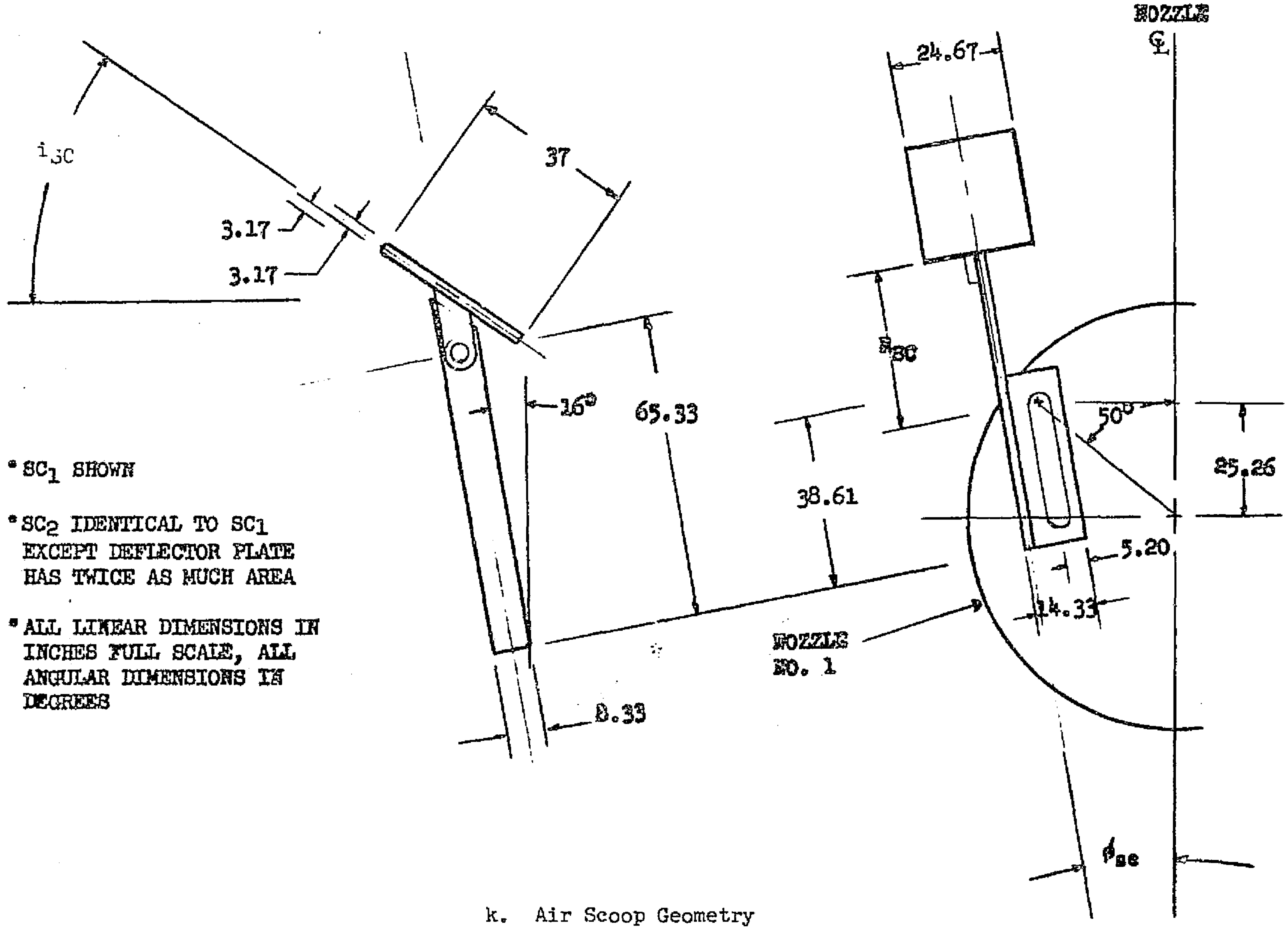


747 HORIZONTAL TAIL SURVEY AT MODEL STATION 82			
PROBE POSITION	MACH .3	.5	
VERT.	95/96	94	RUN NO.
HORIZ.	107	100	

i. Split Film Probe Survey Pattern
Figure 2. Continued.

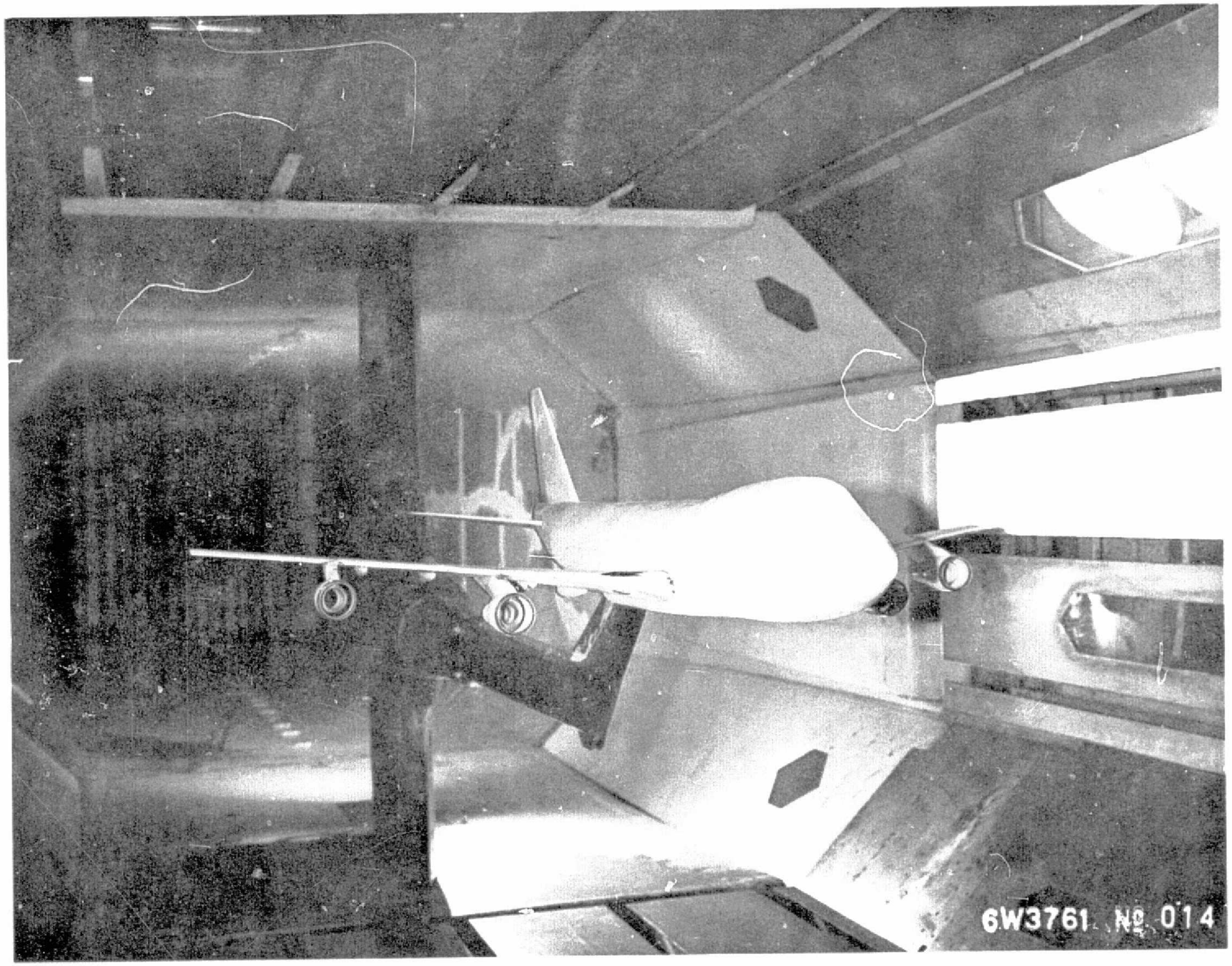


j. Wind Tunnel Test Points
Figure 2. Continued.



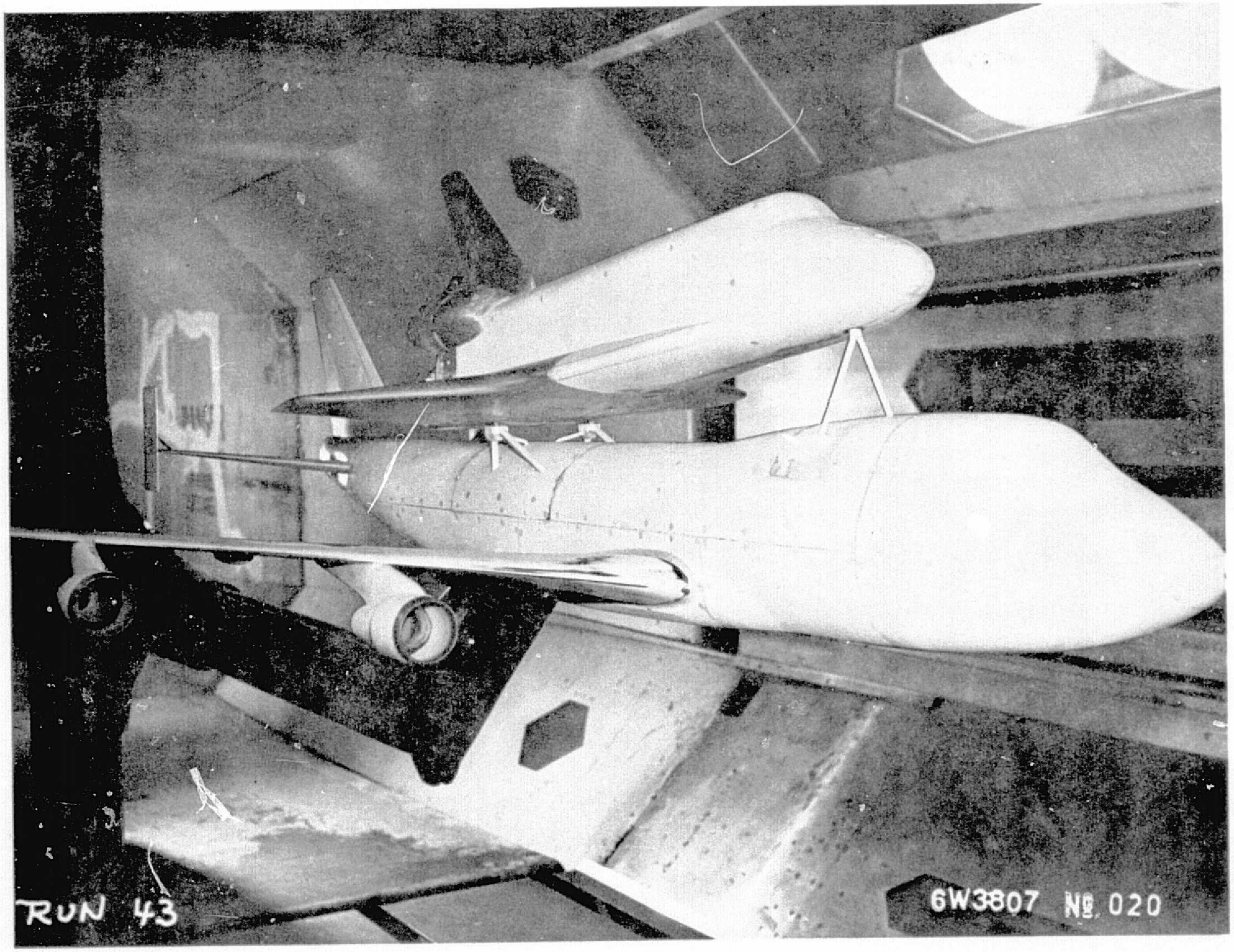
k. Air Scoop Geometry

Figure 2. Concluded.

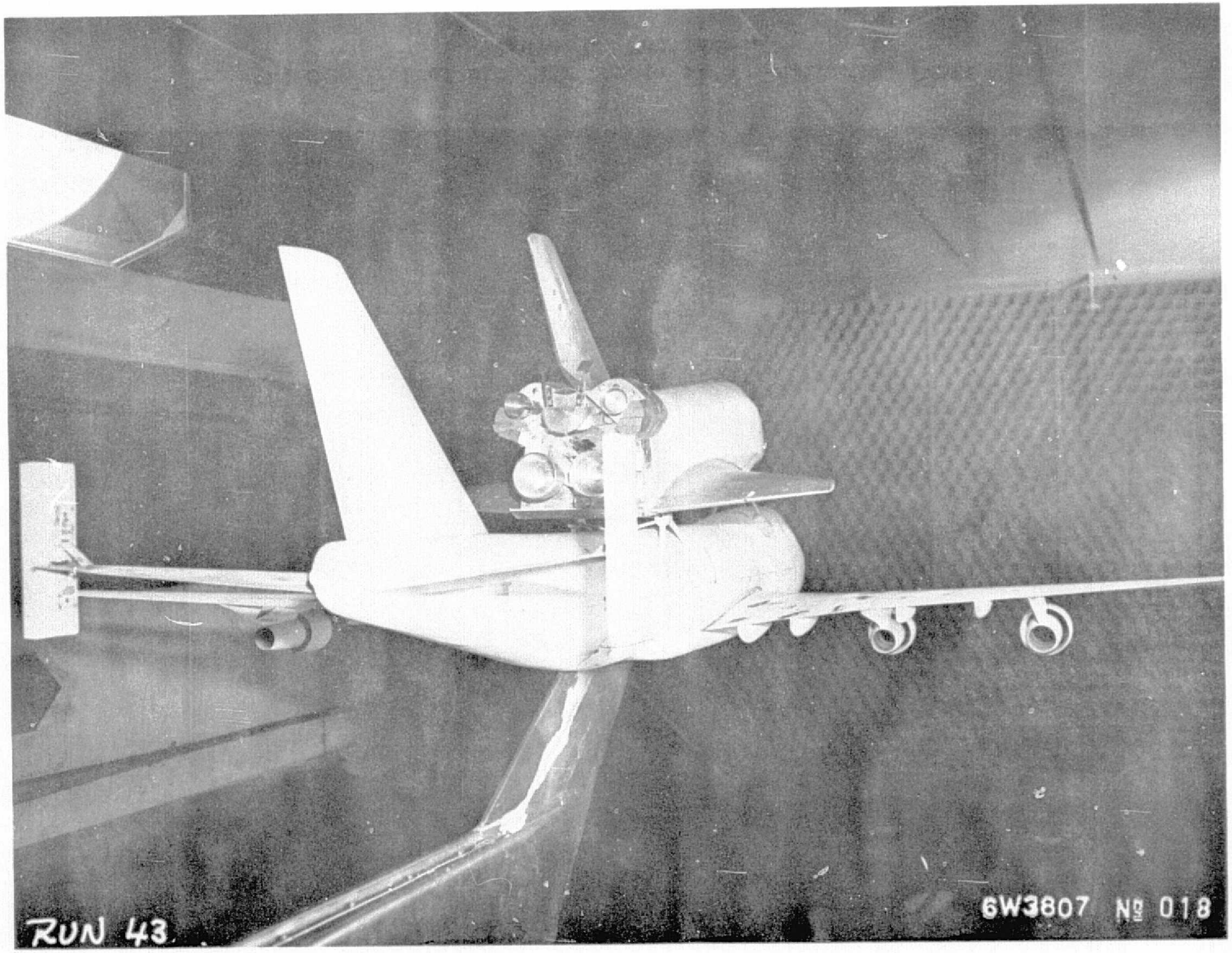


a. 747 CAM/Type 1
Figure 3. Model installation photographs.

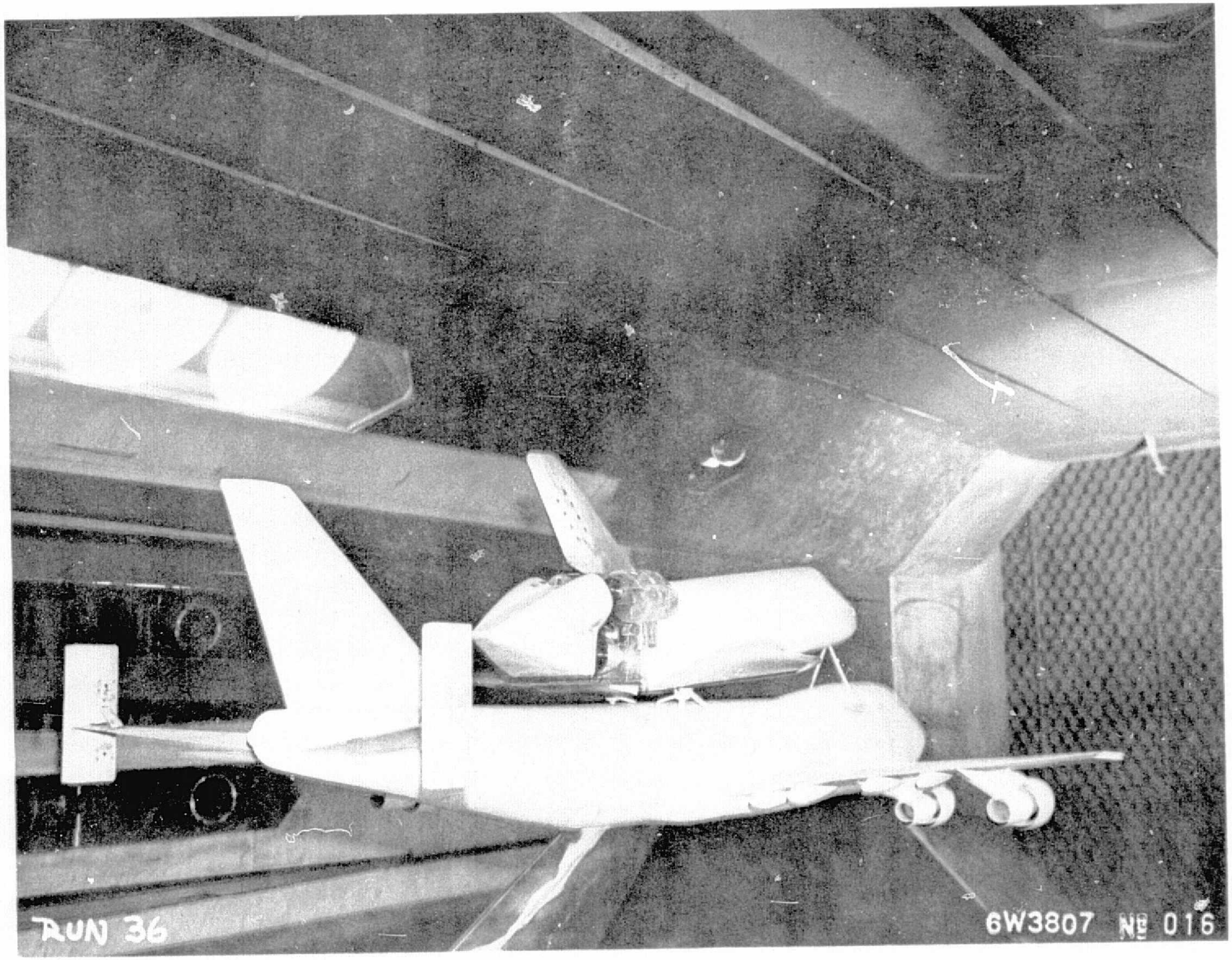
b. 747 CAM/Type 2
Figure 3. Continued.



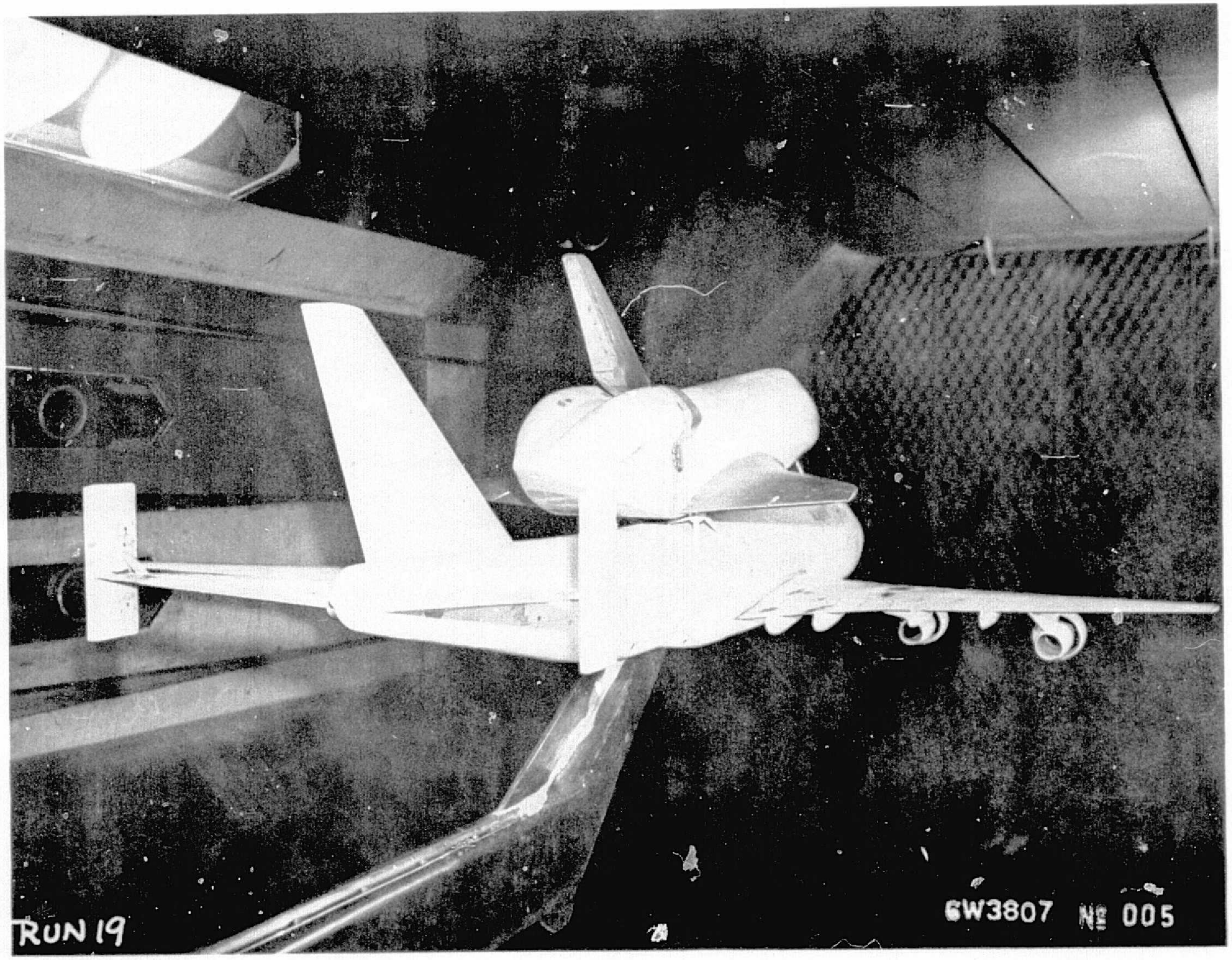
c. 747 CAM/Orbiter with Air Scoops at 6° Incidence, Front View
Figure 3. Continued.



d. 747 CAM/Orbiter with Air Scoops at 6° Incidence, Rear View
Figure 3. Continued.

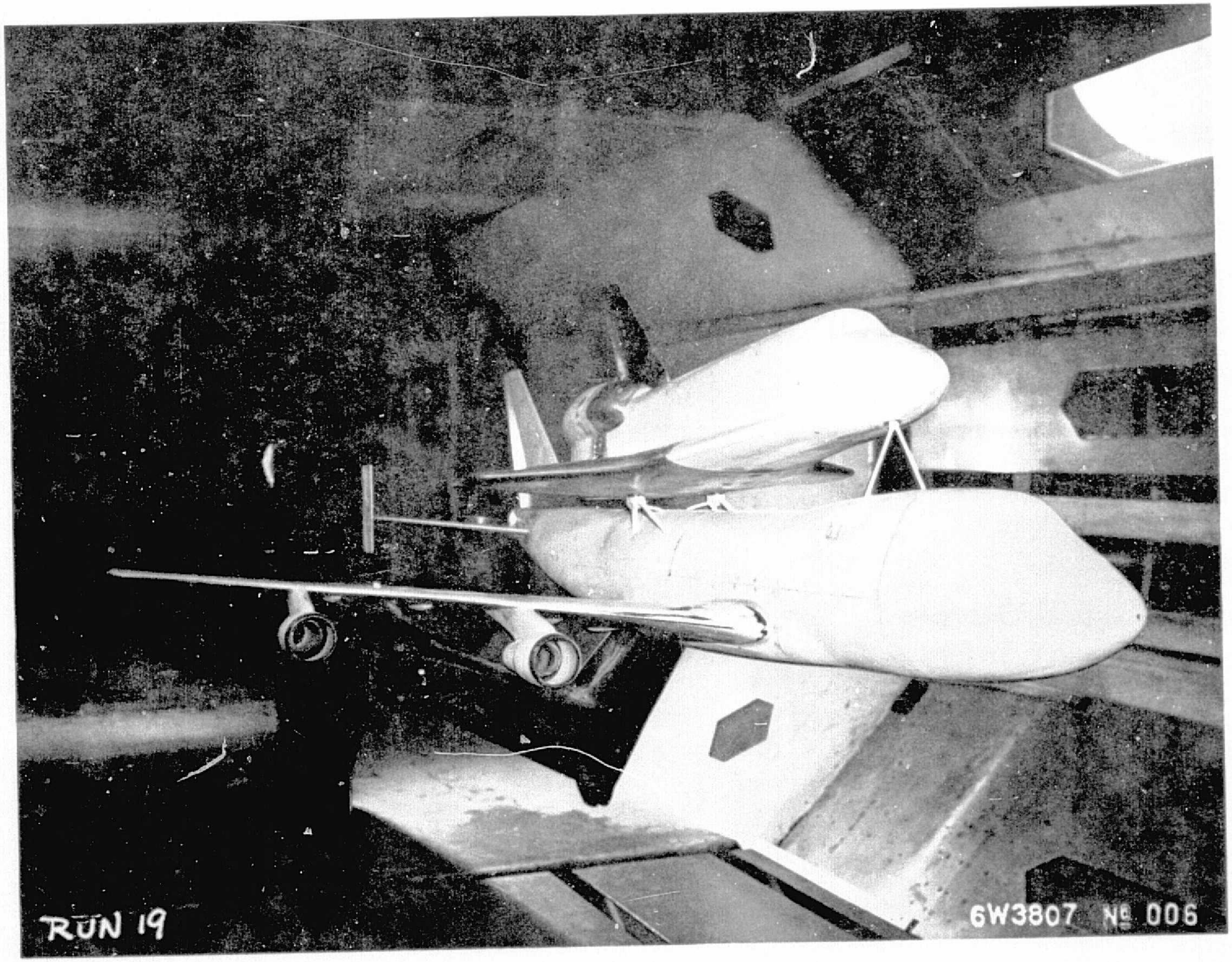


e. 747 CAM/Orbiter with Partial Tailcone, 6° Orbiter Incidence
Figure 3. Continued.

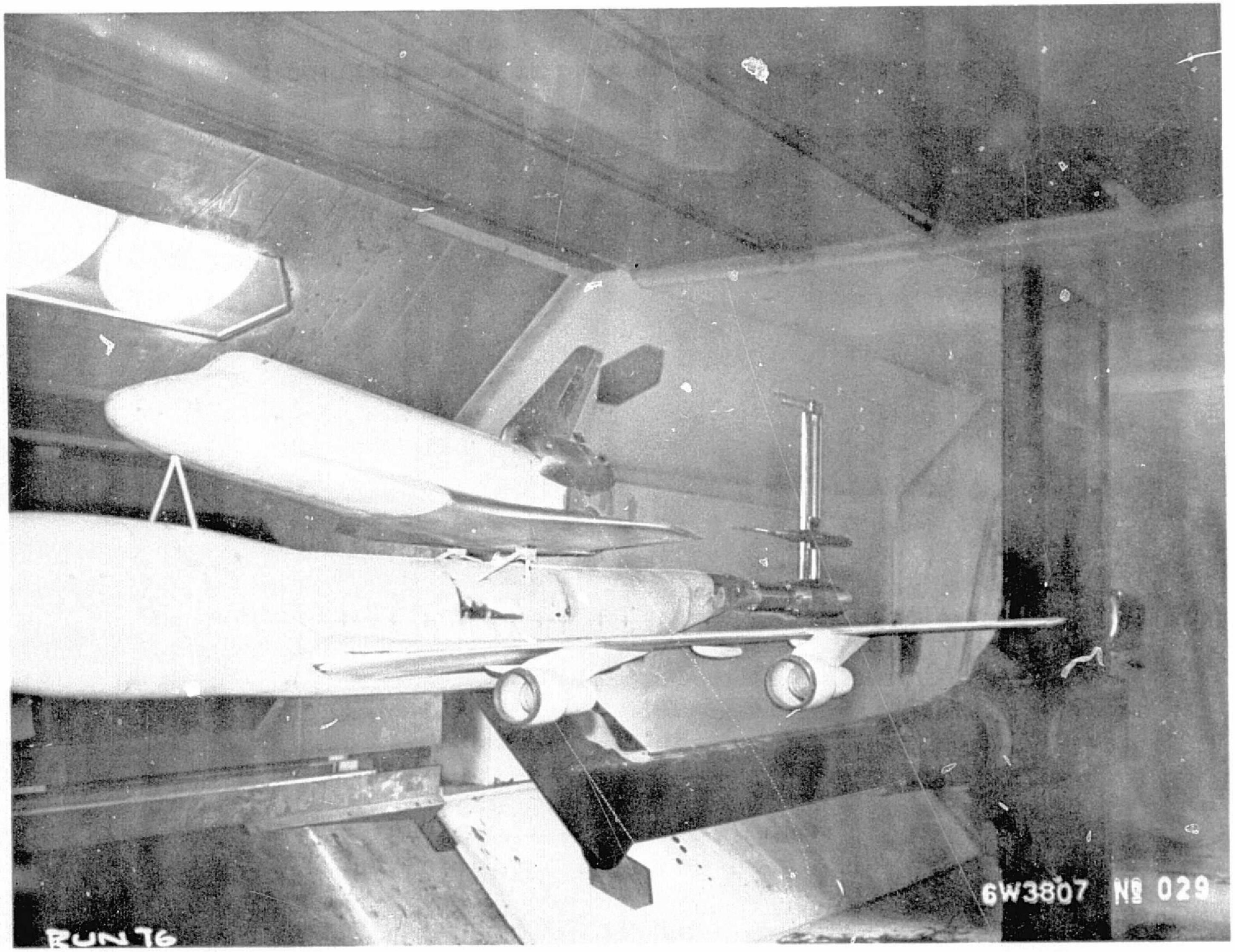


f. 747 CAM/Orbiter with Tailcone at 6° Incidence, Front View

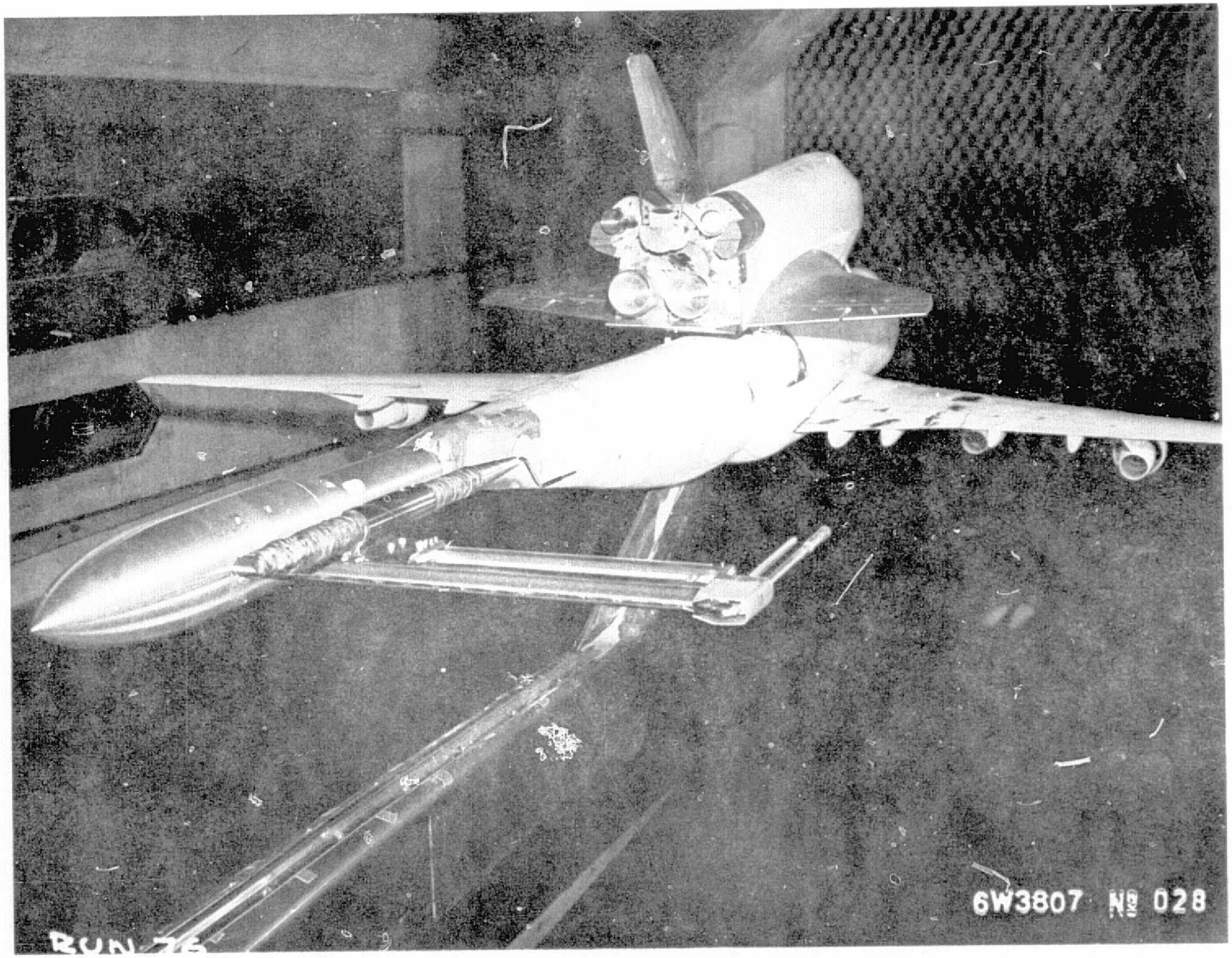
Figure 3. Continued.



g. 747 CAM/Orbiter with Tailcone at 6° Incidence, Rear View
Figure 3. Continued.

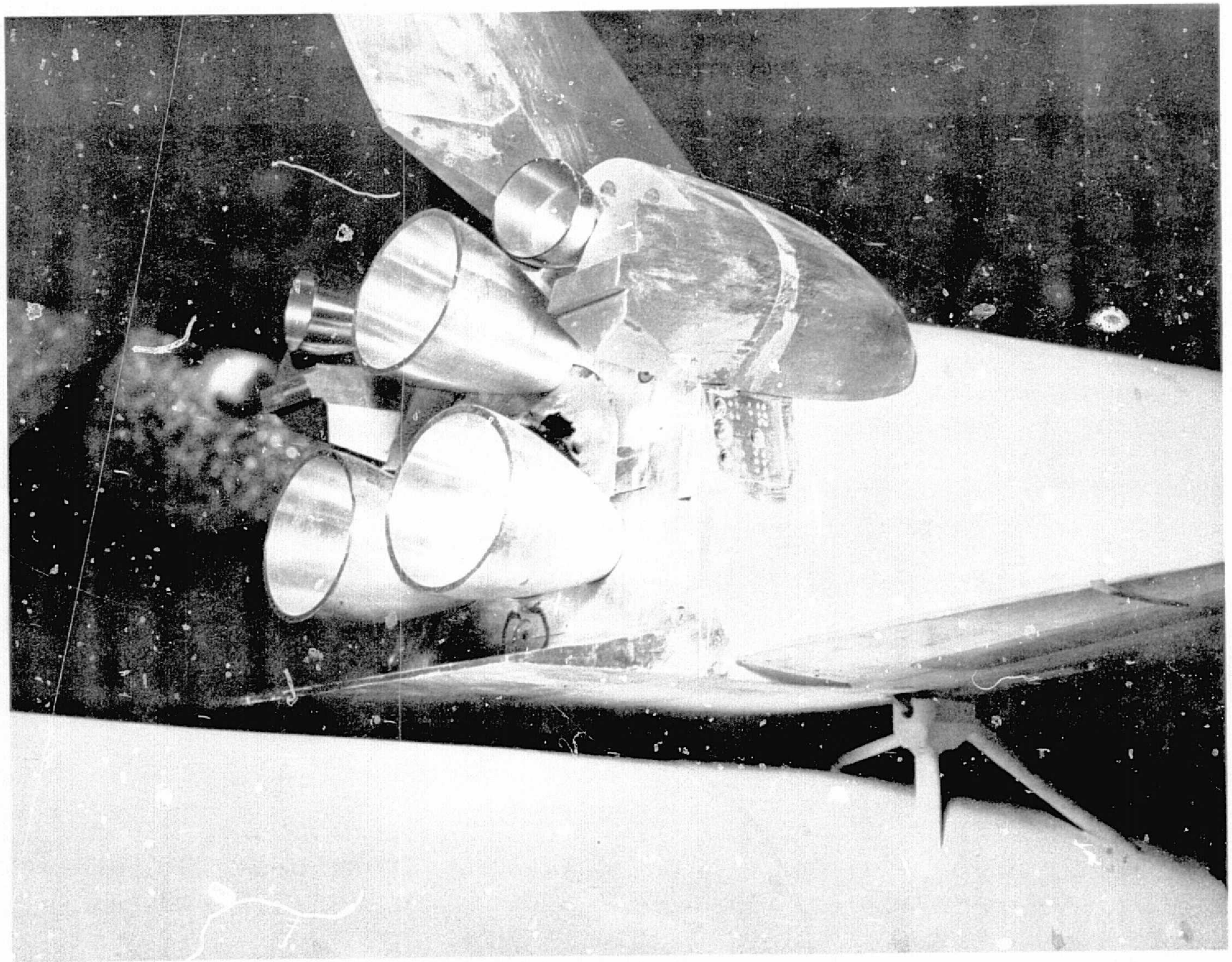


h. Wake Survey Mechanism Installation, Front View
Figure 3. Continued.

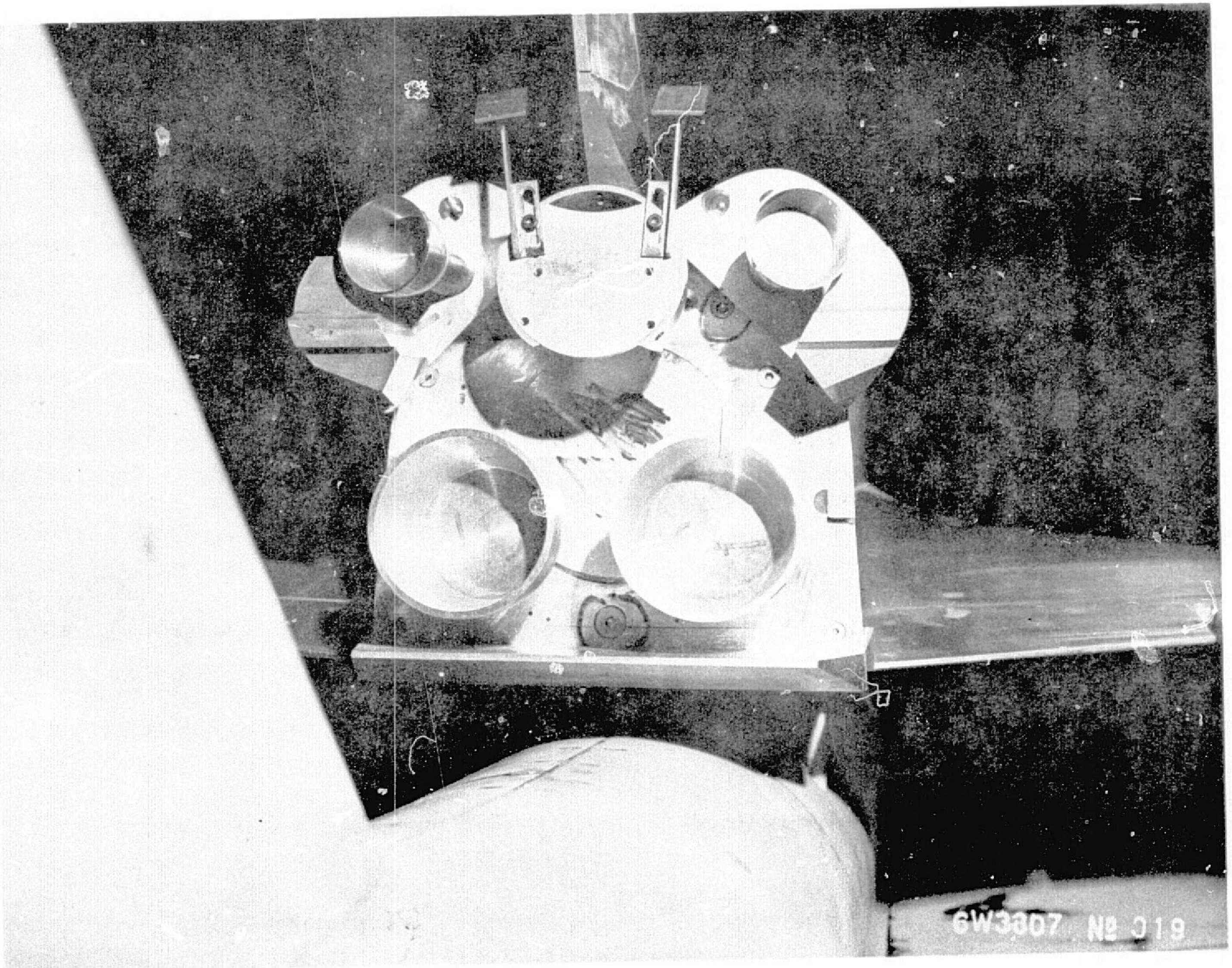


i. Wake Survey Mechanism Installation, Rear View

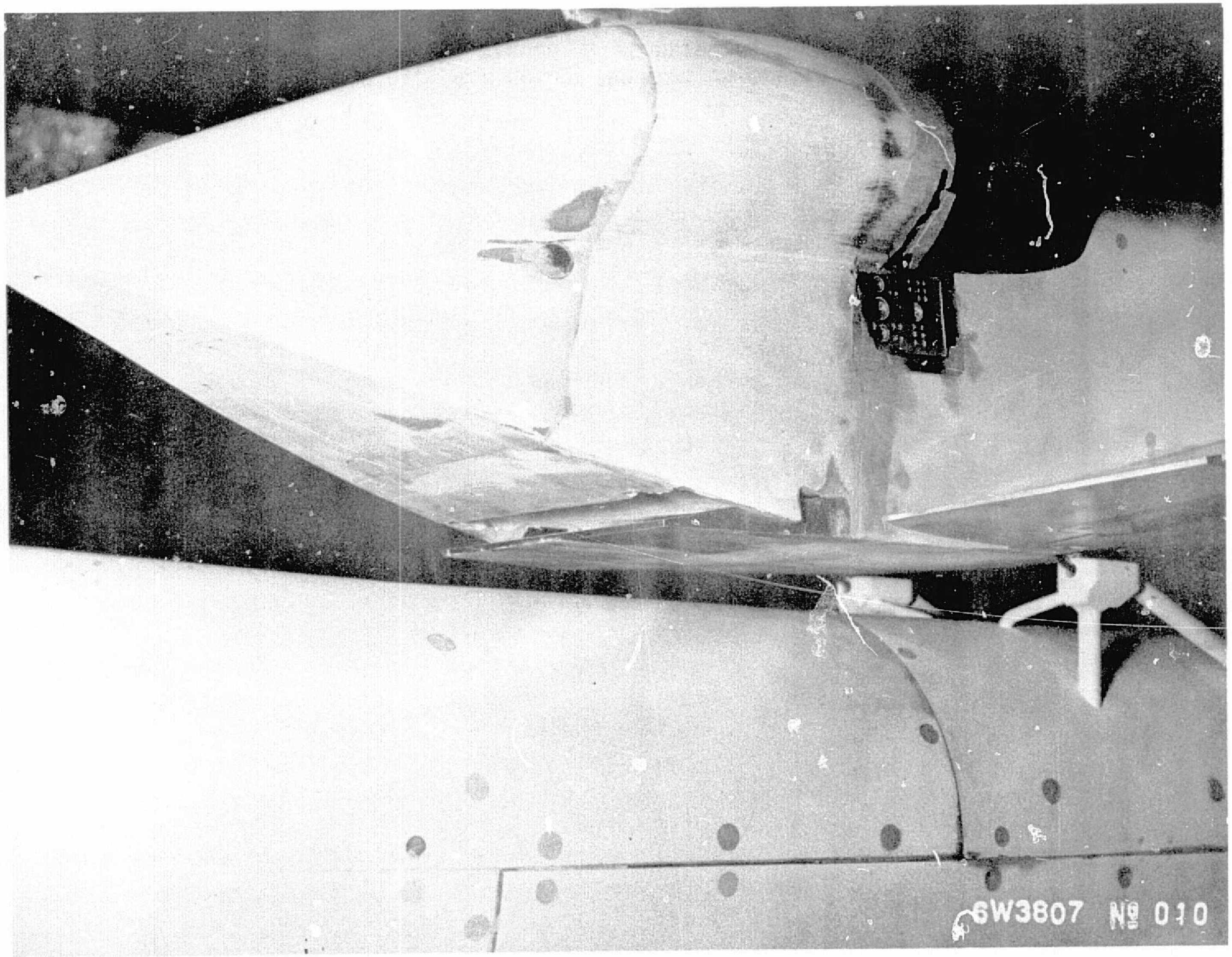
Figure 3. Continued.



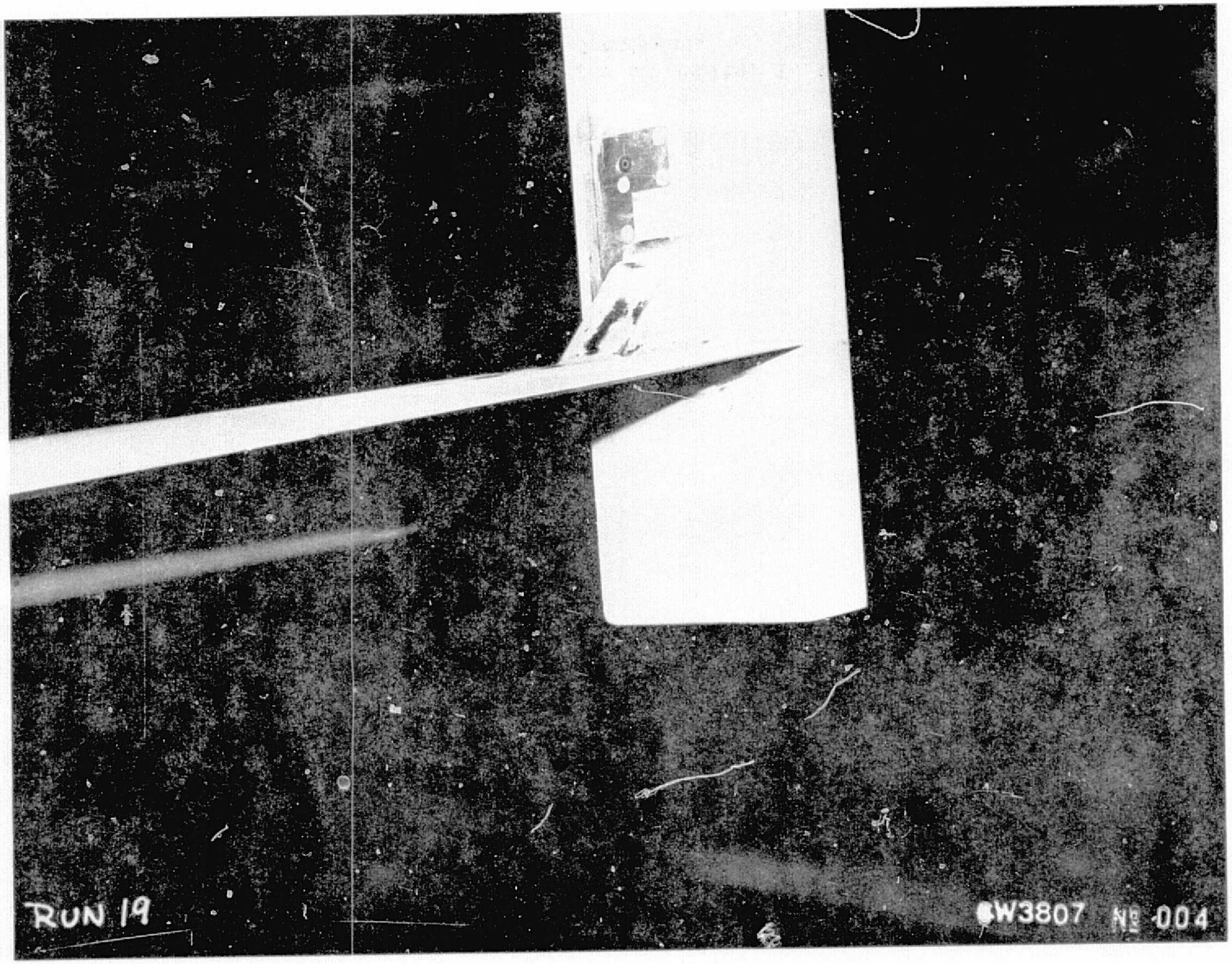
j. Orbiter Base with Tailcone Removed
Figure 3. Continued.



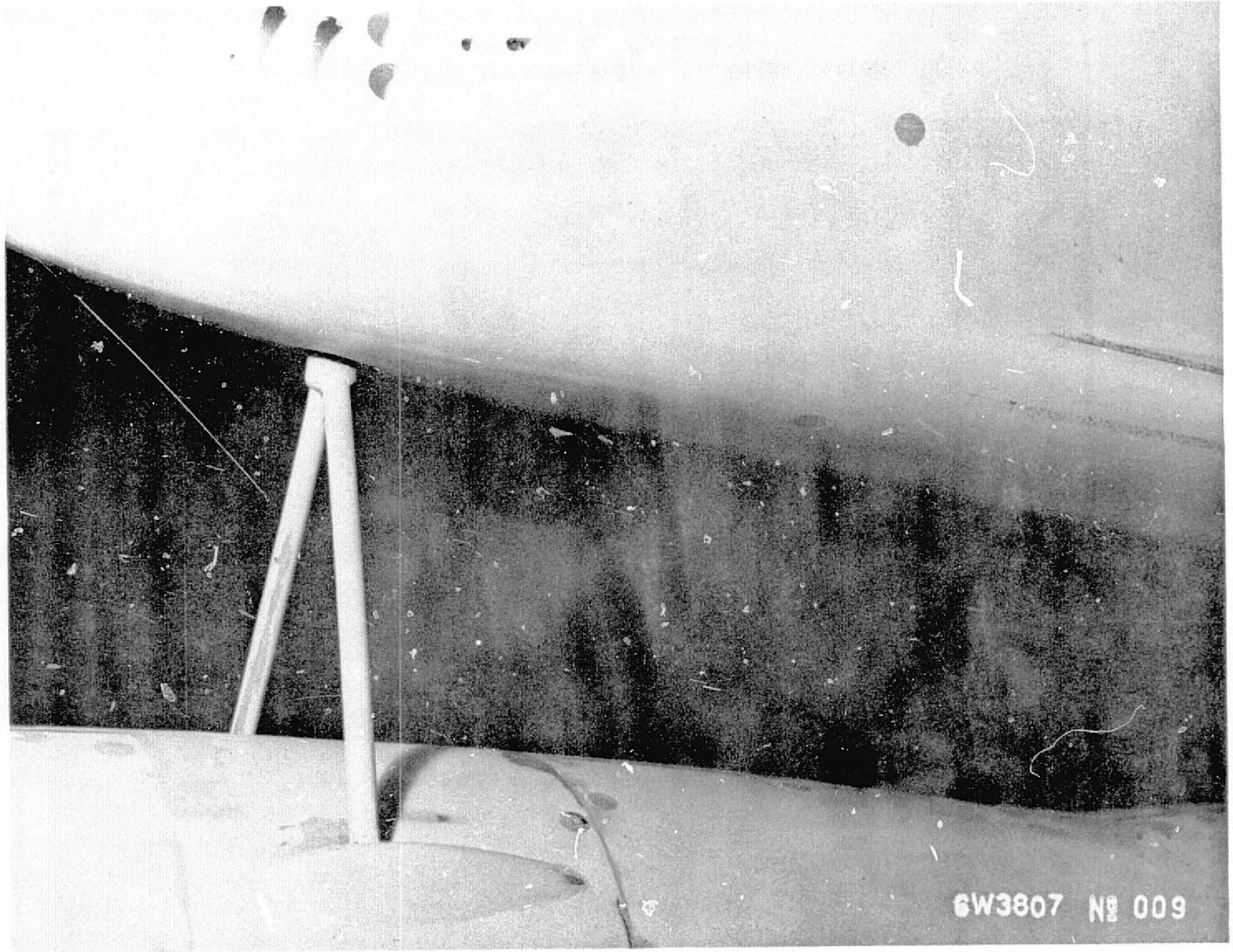
k. Air Scoops Mounted on Orbiter
Figure 3. Continued.



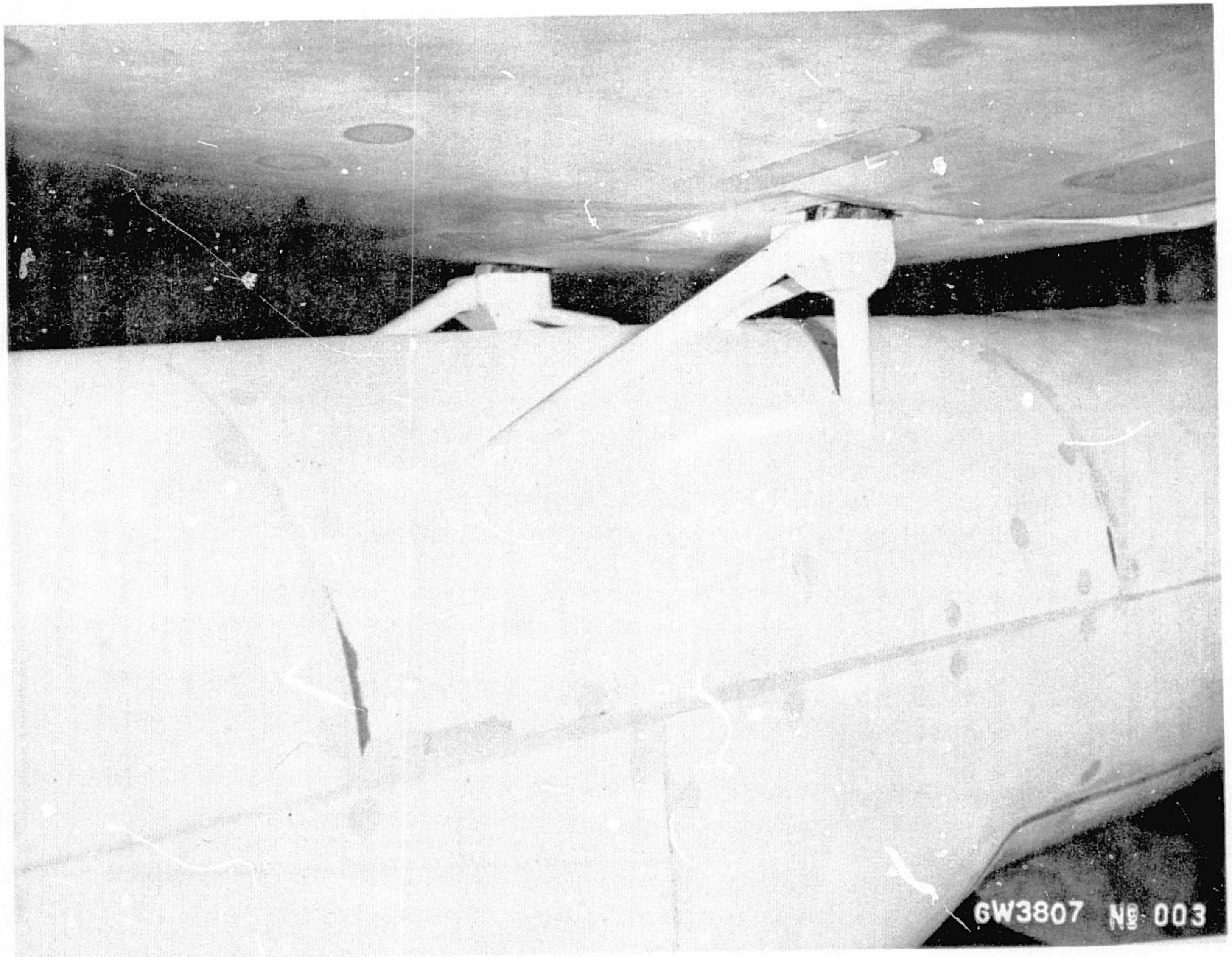
1. Tailcone Installed on Orbiter
Figure 3. Continued.



m. 747 CAM/Type 2 Tip Fin Installation
Figure 3. Continued.



n. Forward Support Strut for 6° Orbiter Incidence
Figure 3. Continued.



o. Aft Support Strut for 6° Orbiter Incidence
Figure 3. Concluded.

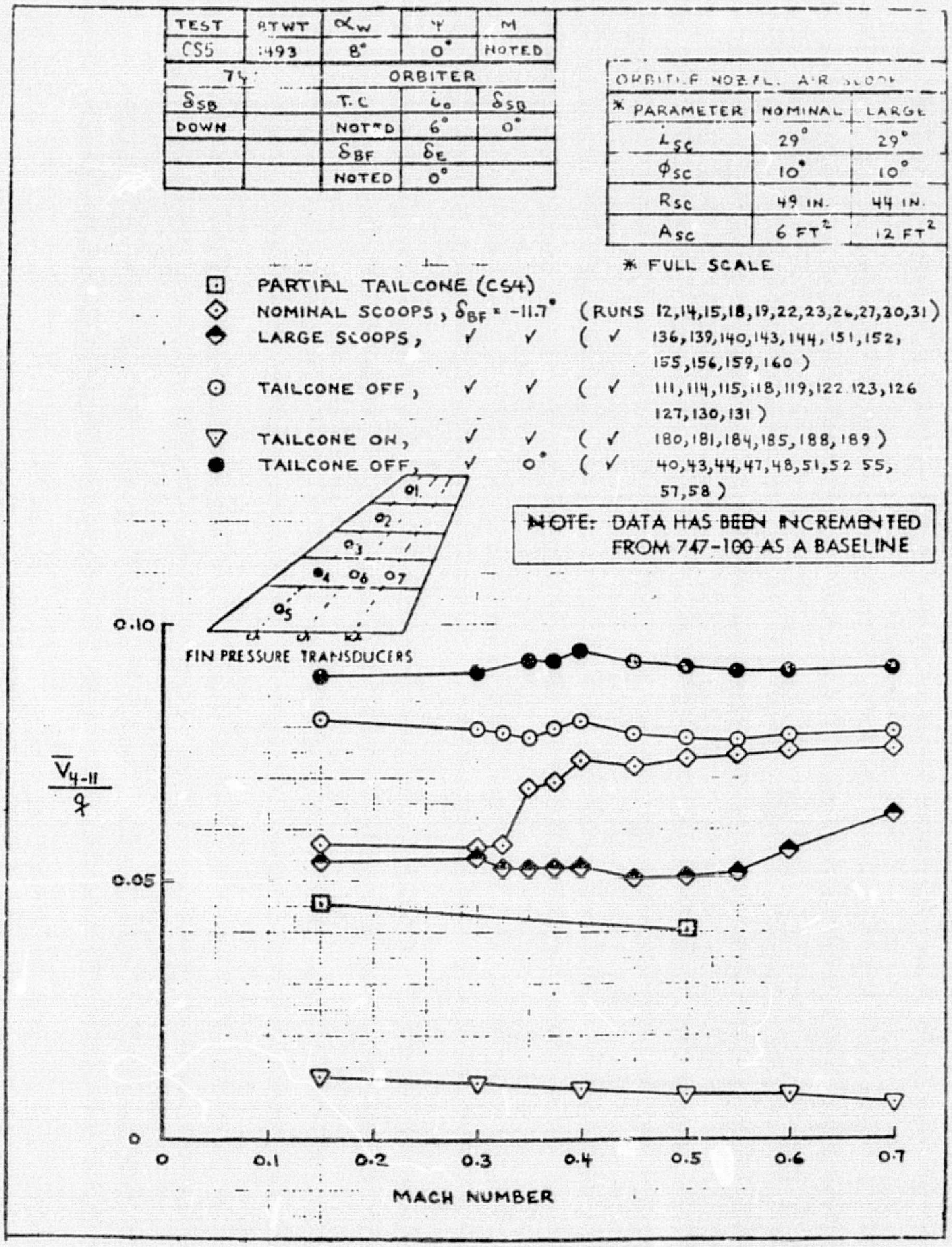


Figure 4. Summary of 747 vertical tail RMS differential pressure coefficients.

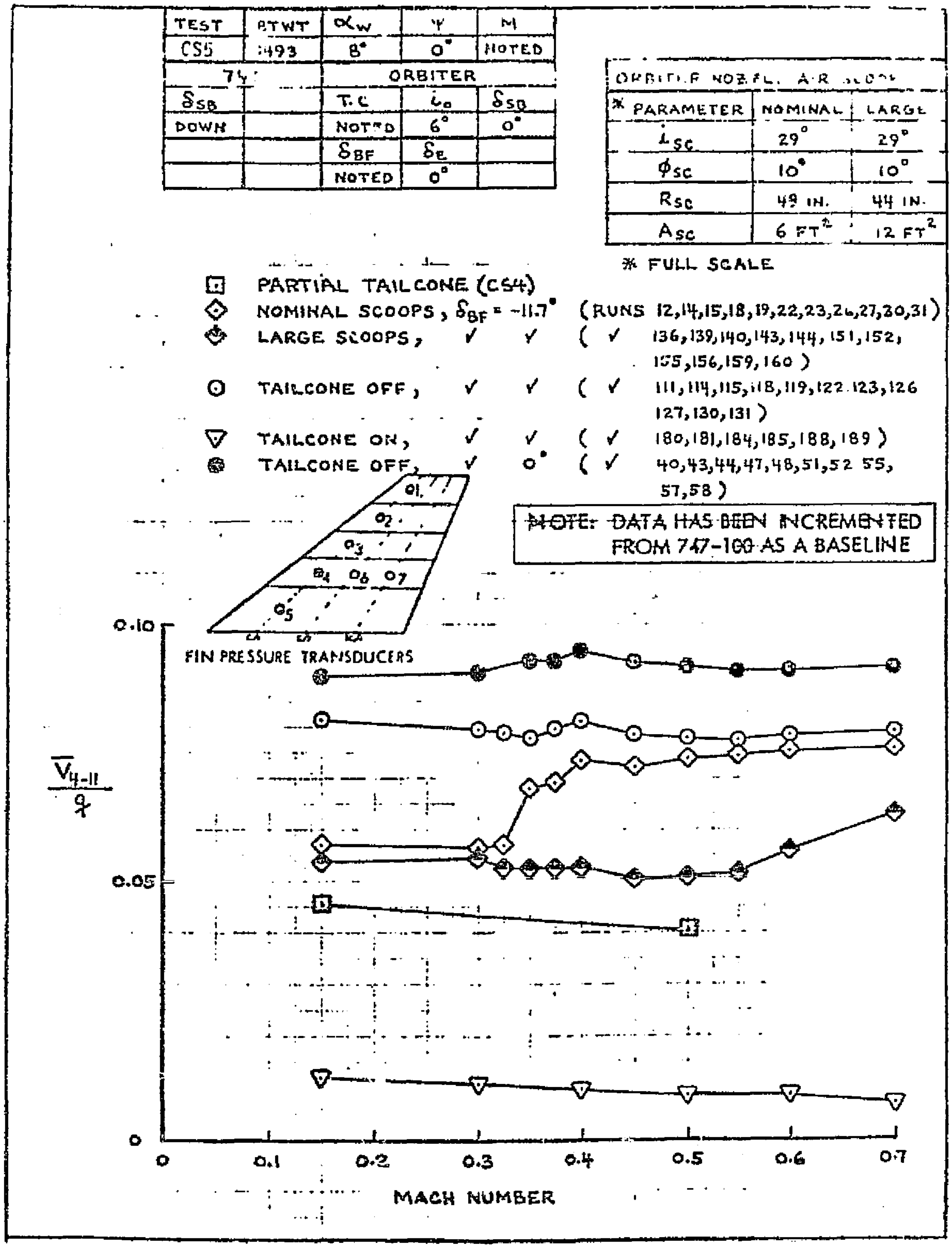


Figure 4. Summary of 747 vertical tail RMS differential pressure coefficients.

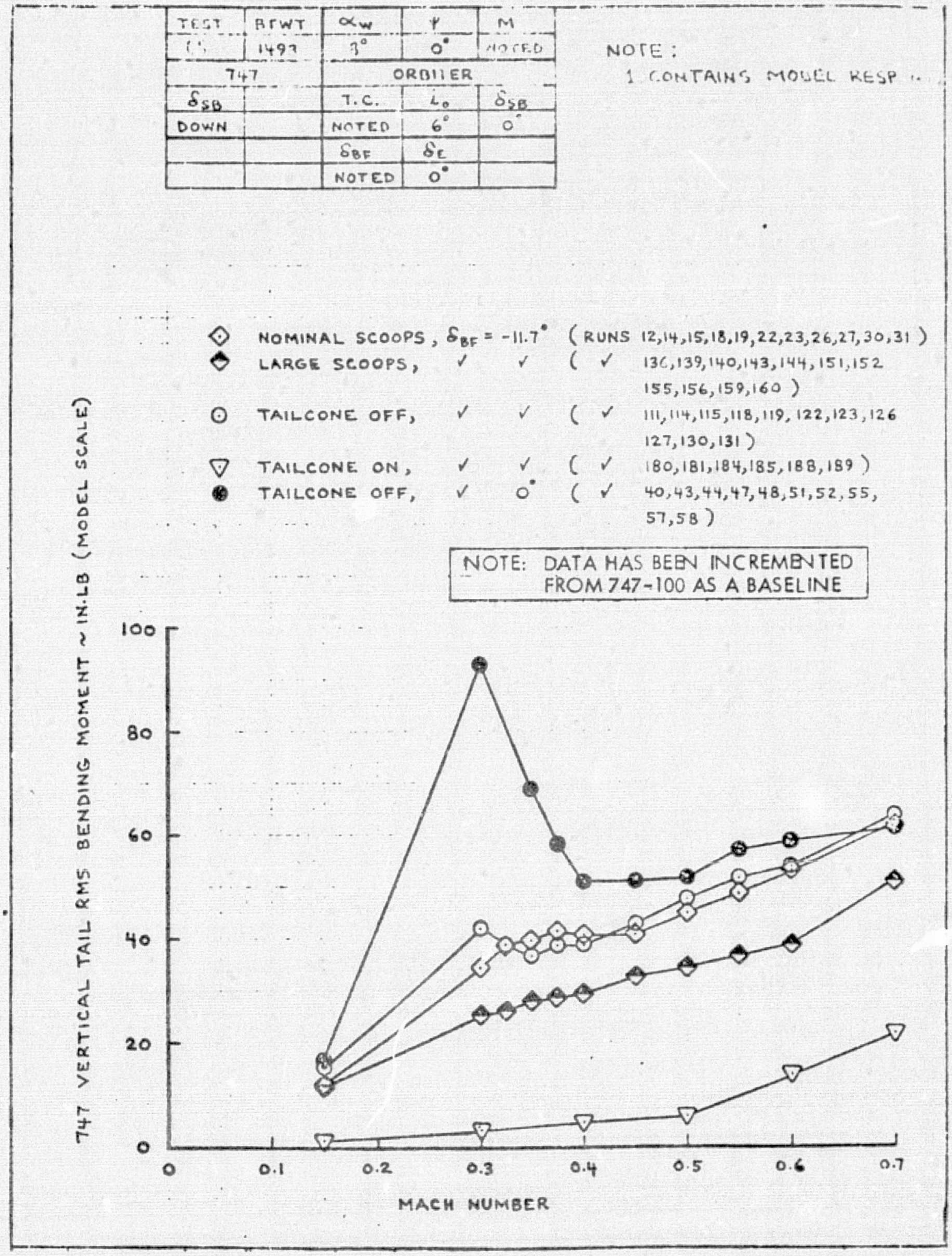


Figure 5. Summary of 747 vertical tail RMS bending moments at W. L 379.3.

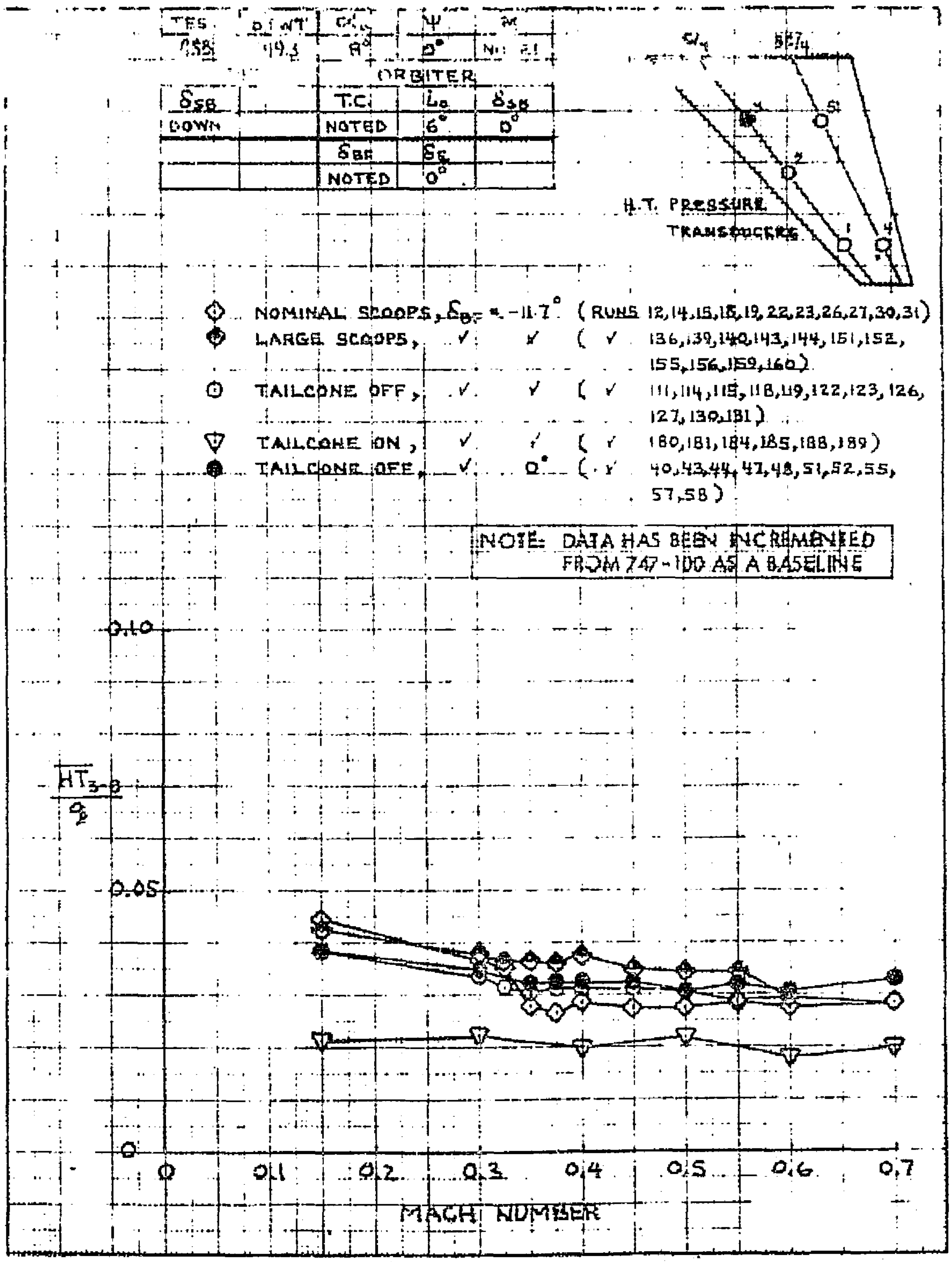


Figure 6. Summary of 747 horizontal tail RMS differential pressure coefficients.

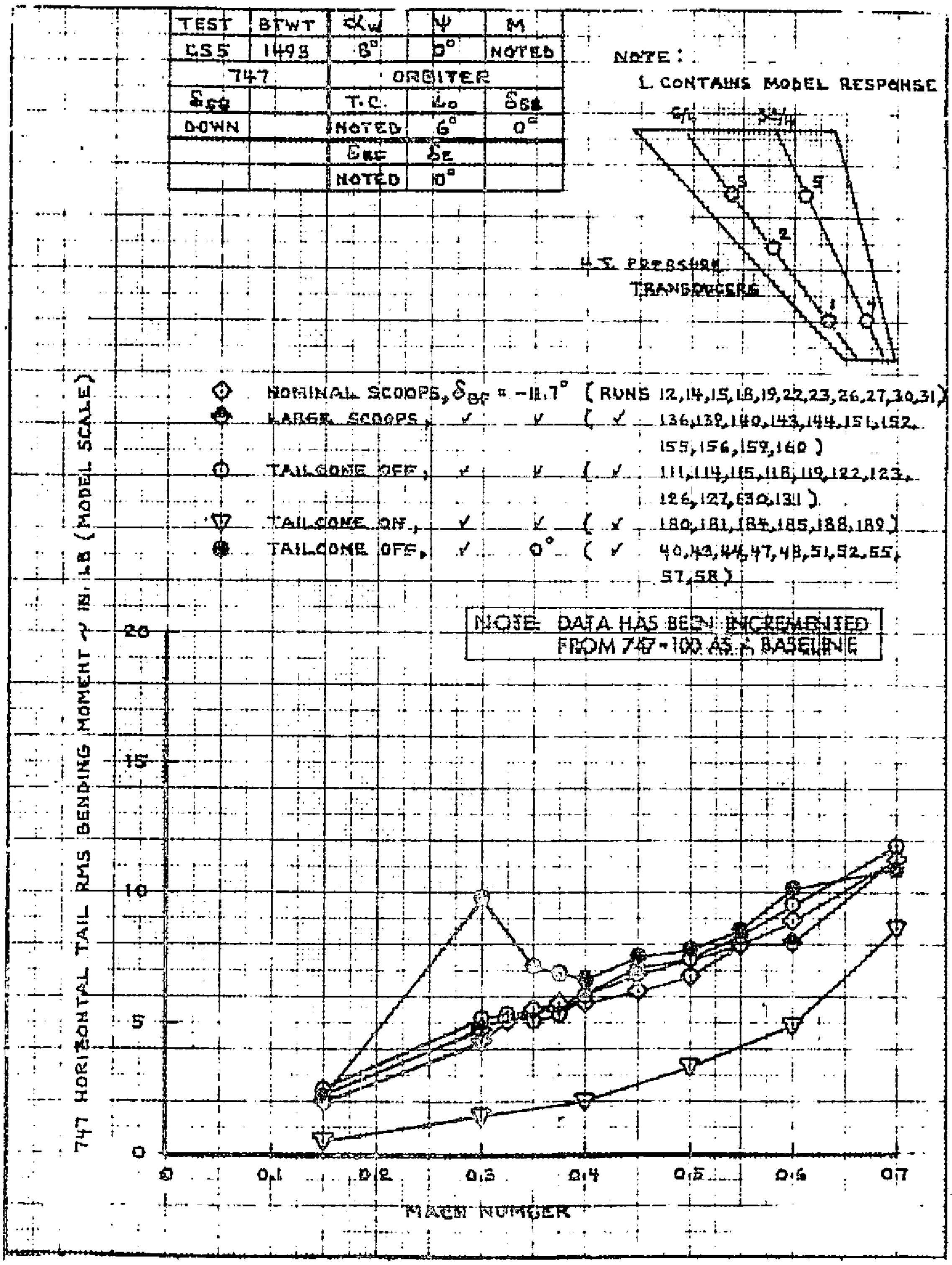


Figure 7. Summary of 747 horizontal tail RMS bending moments at B. L. 58.3.

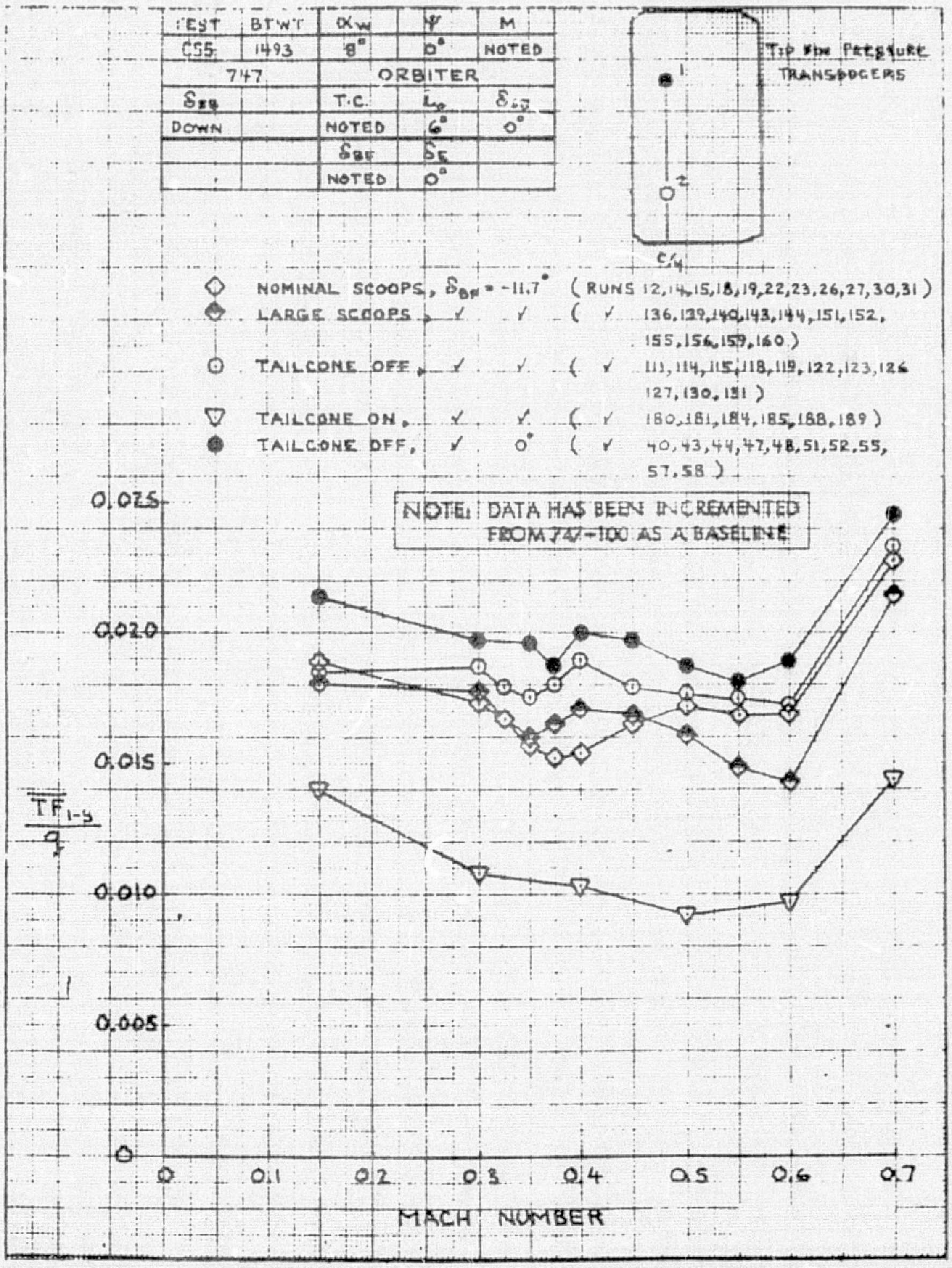


Figure 8. Summary of 747 tip fin RMS differential pressure coefficients.

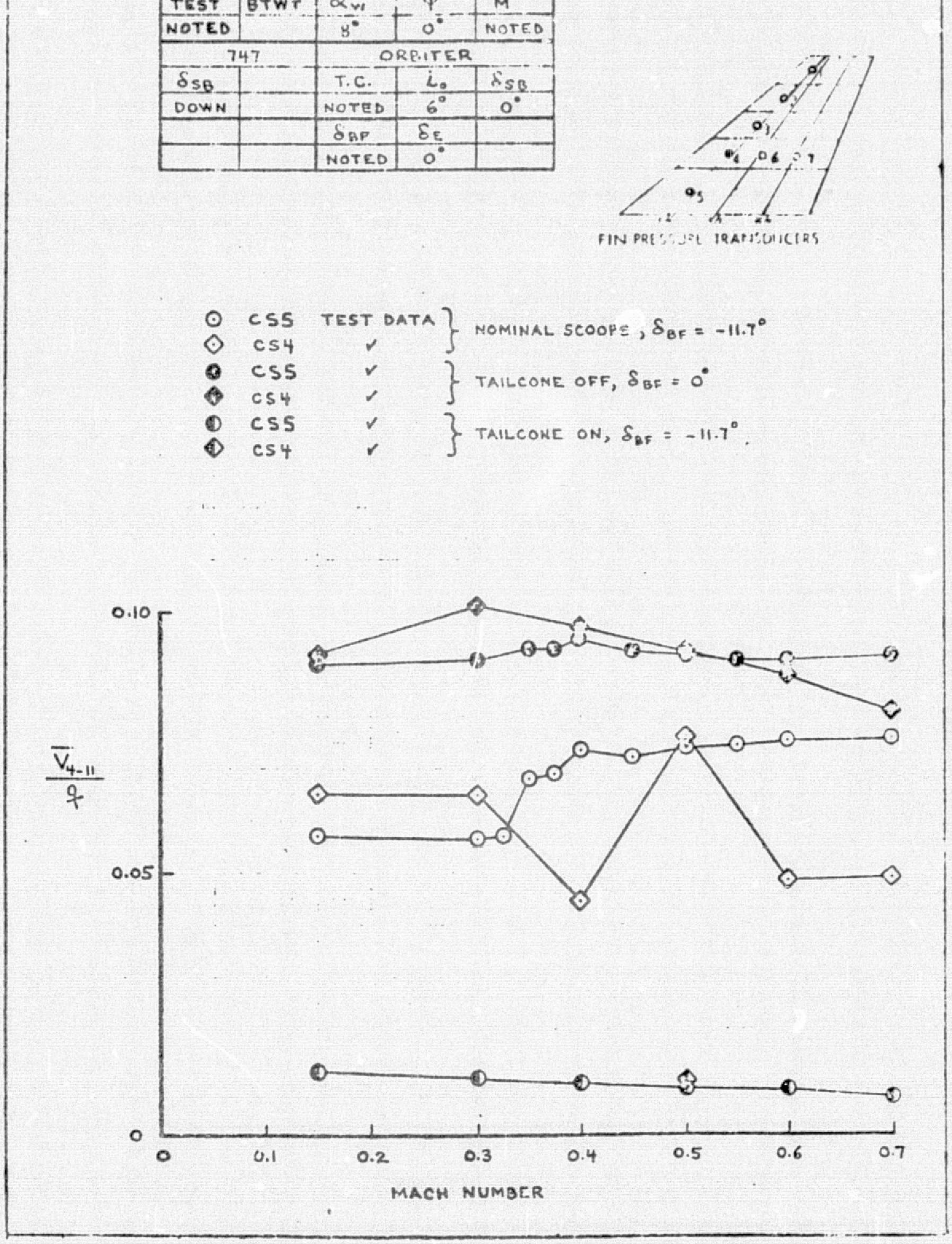
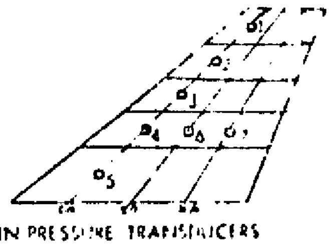


Figure 9. Comparison of CS4 and CS5 vertical tail test results.

TEST	BTWT	α_W	ψ	M
CS5	1493	8°	0°	NOTED
747		ORBITER		
δ_{SB}		T.C.	i_o	δ_{SB}
DOWN		OFF	6°	0°
		δ_{BF}	δ_E	
		NOTED	0°	



DATA IS NOT CORRECTED FOR ELECTRICAL OR TUNNEL NOISE.

NOMINAL SCOOPS, $\delta_{BF} = -11.7°$, RUN 10
✓ ✓ ✓ ✓ 133
LARGE ✓ ✓ RUNS 135, 175

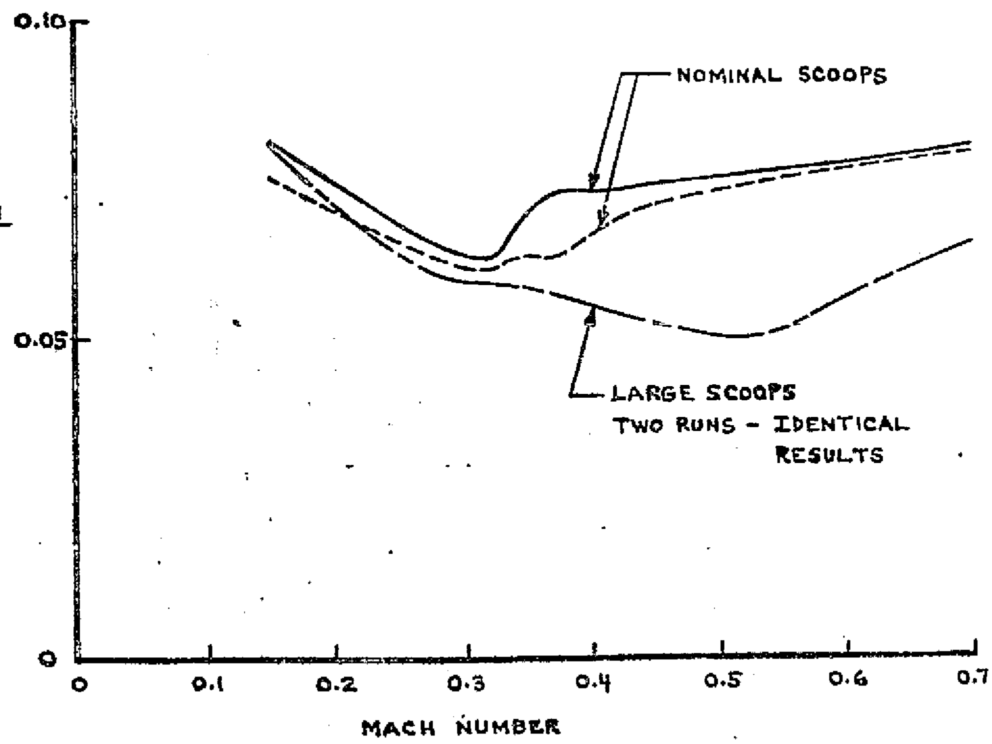


Figure 10. Data repeatability for the CS5 test.

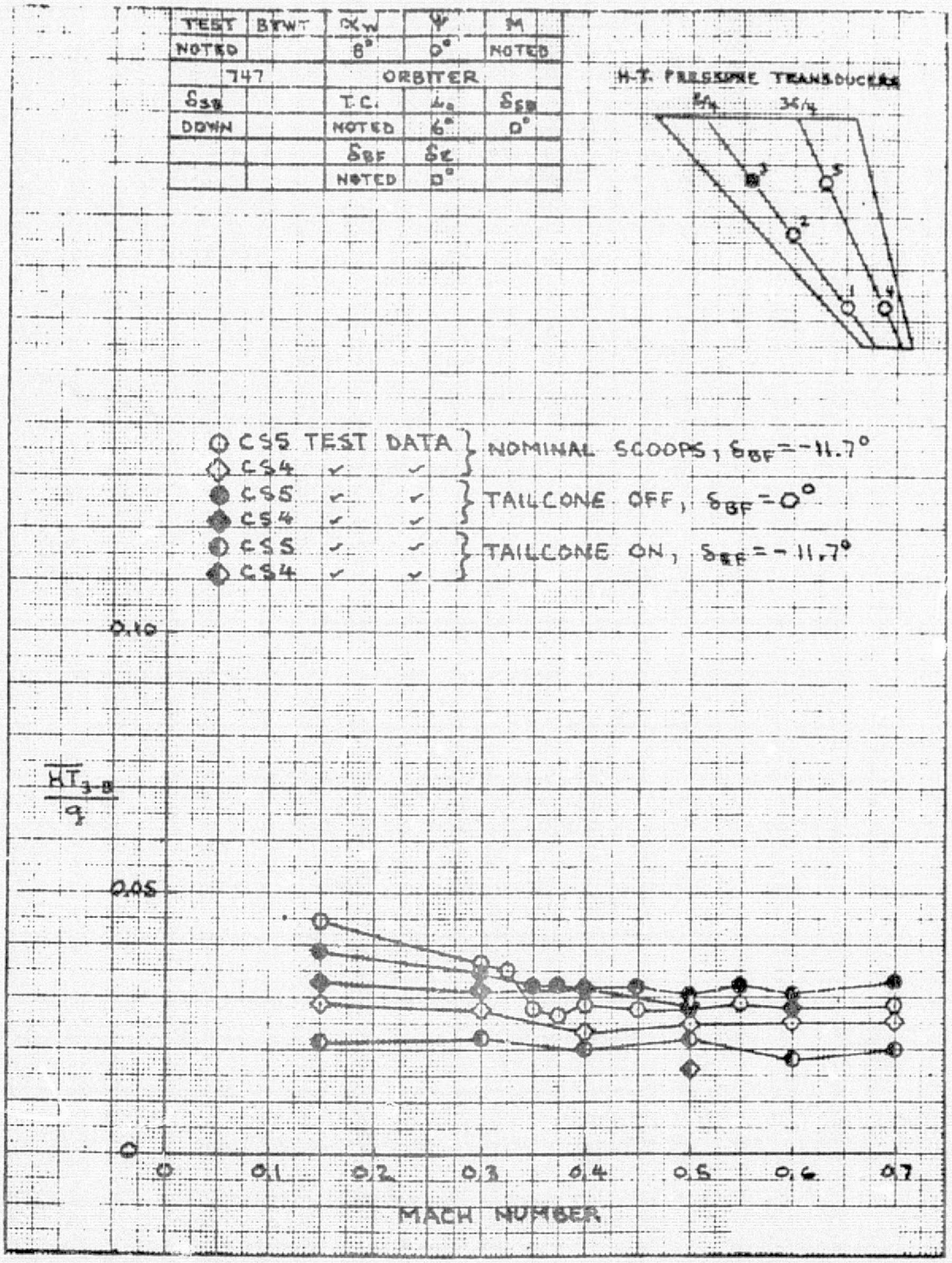


Figure 11. Comparison of CS4 and CS5 horizontal tail test results.

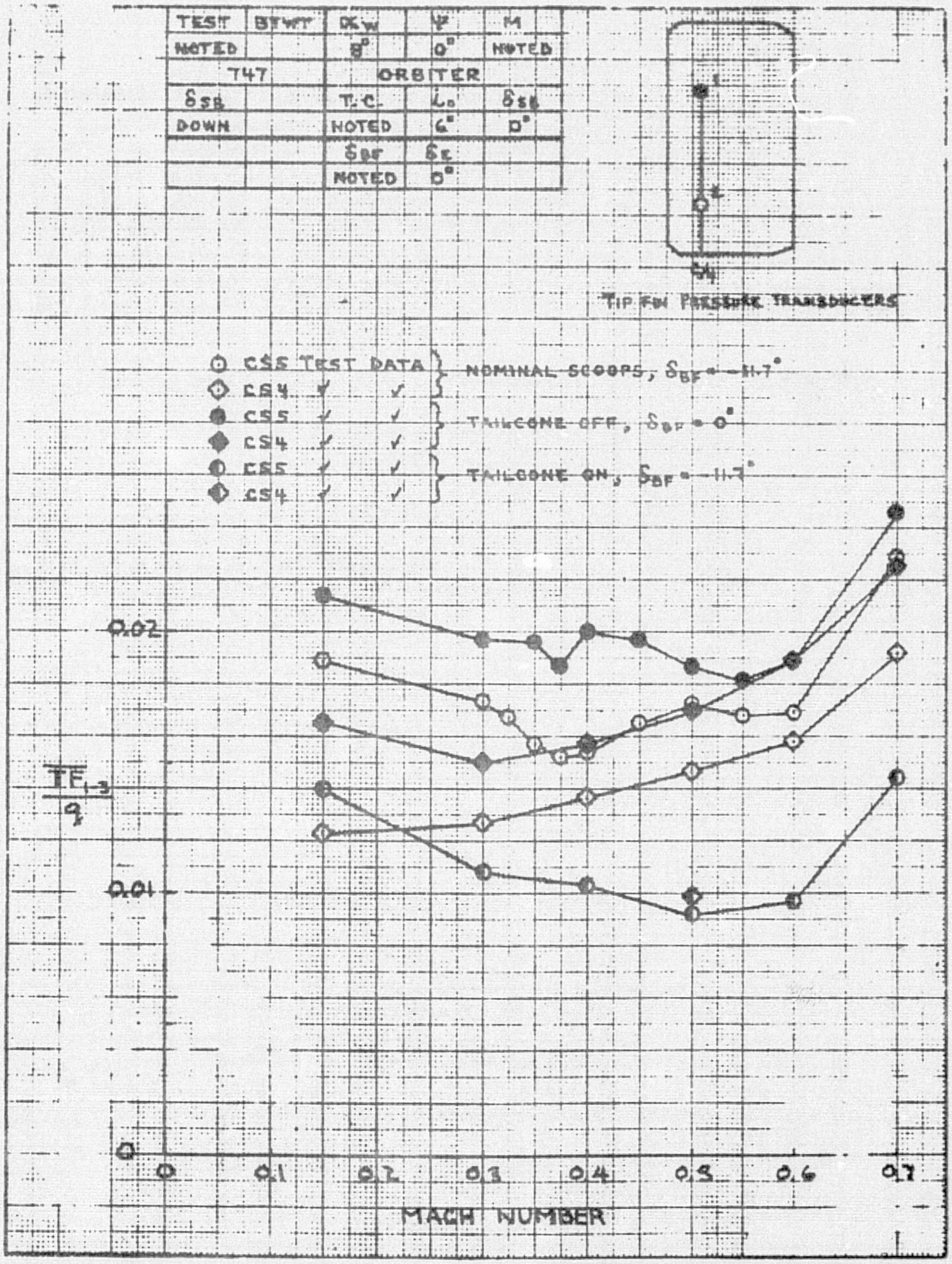


Figure 12. Comparison of CS4 and CS5 tip fin test results.

C.2

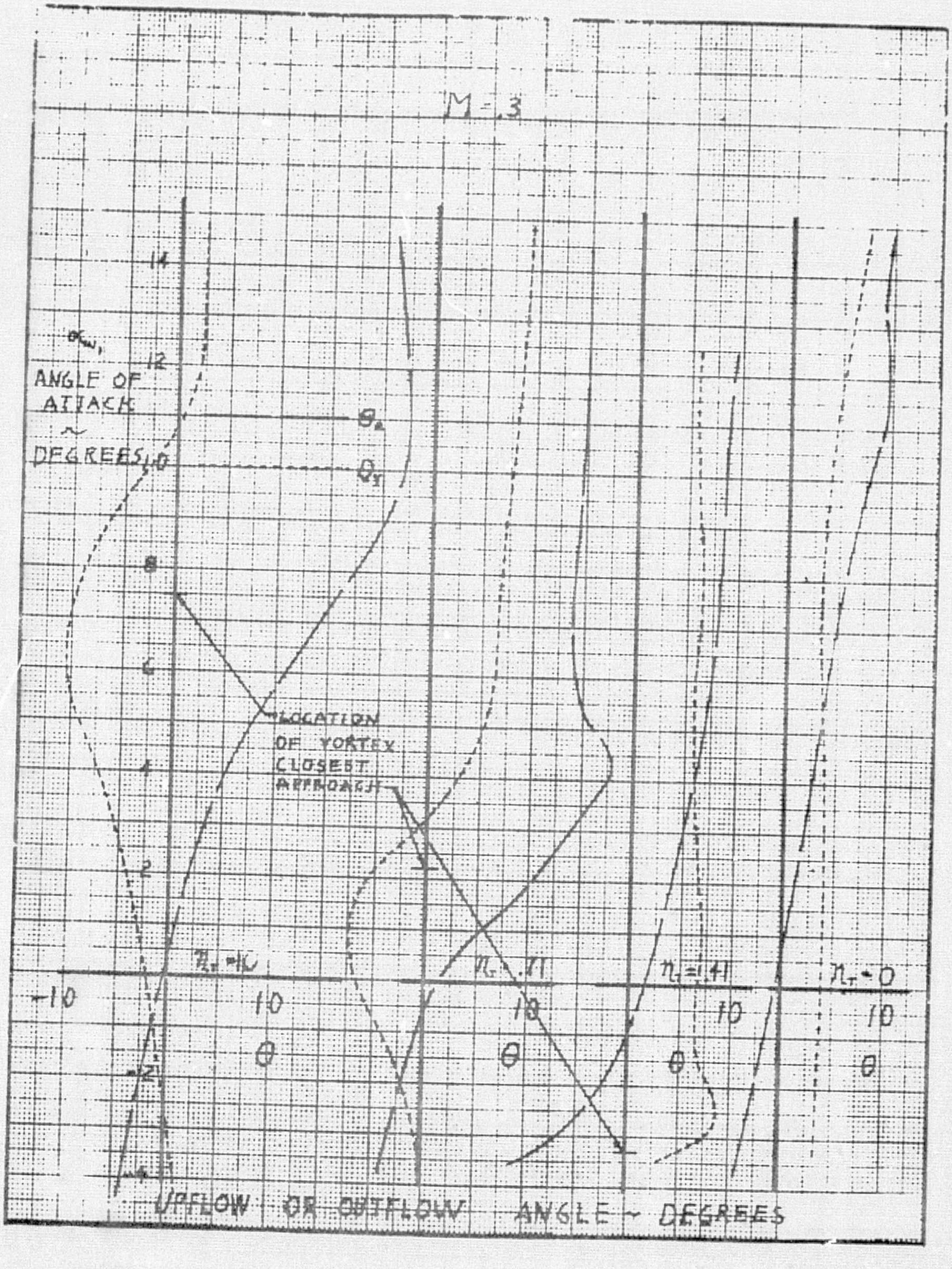


Figure 13. Flow angle at the 747 CAM tip fins, $i_o = 6^o$.

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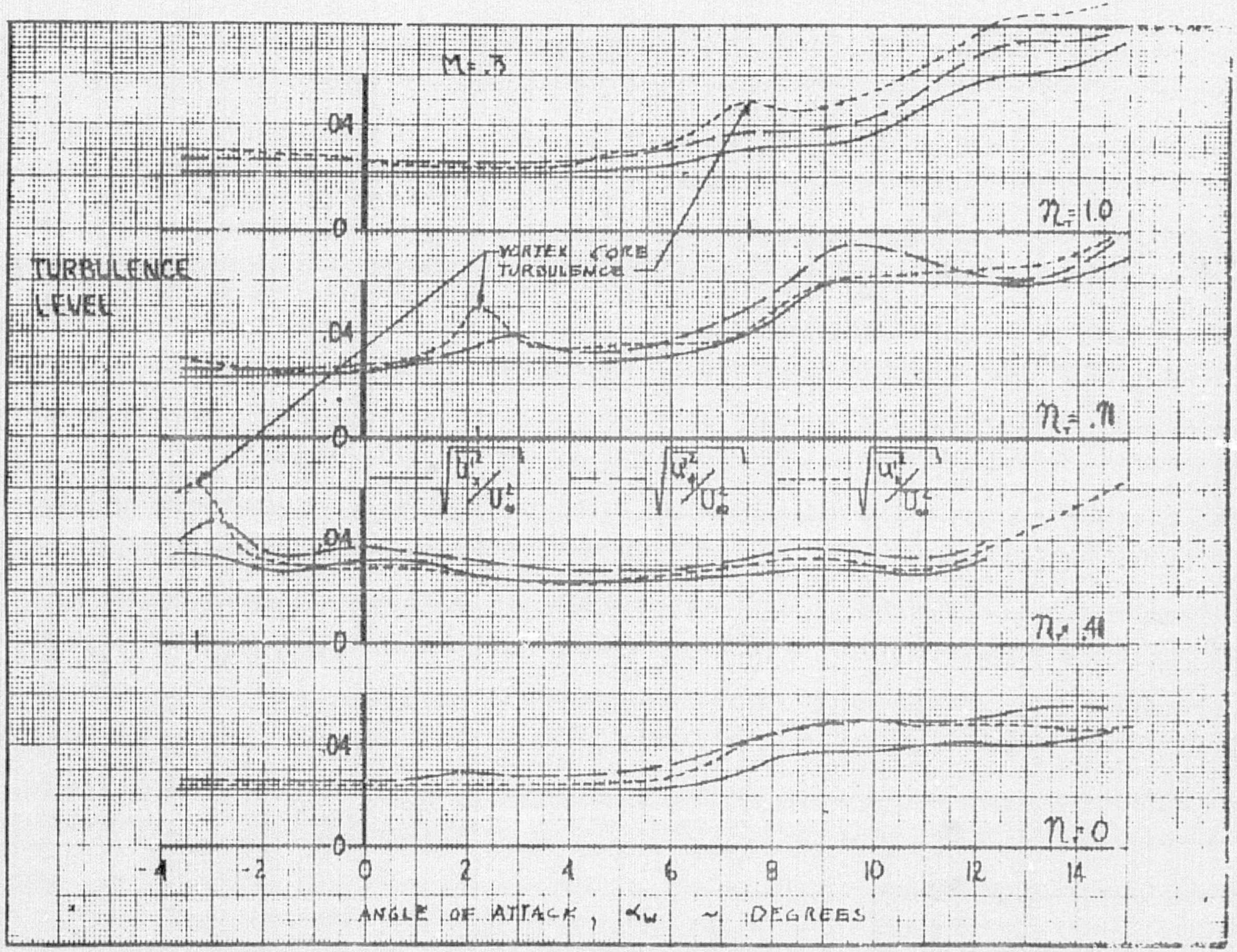

Figure 14. Turbulence level at the 747 CAM tip fins. $i_o = 6^o$.

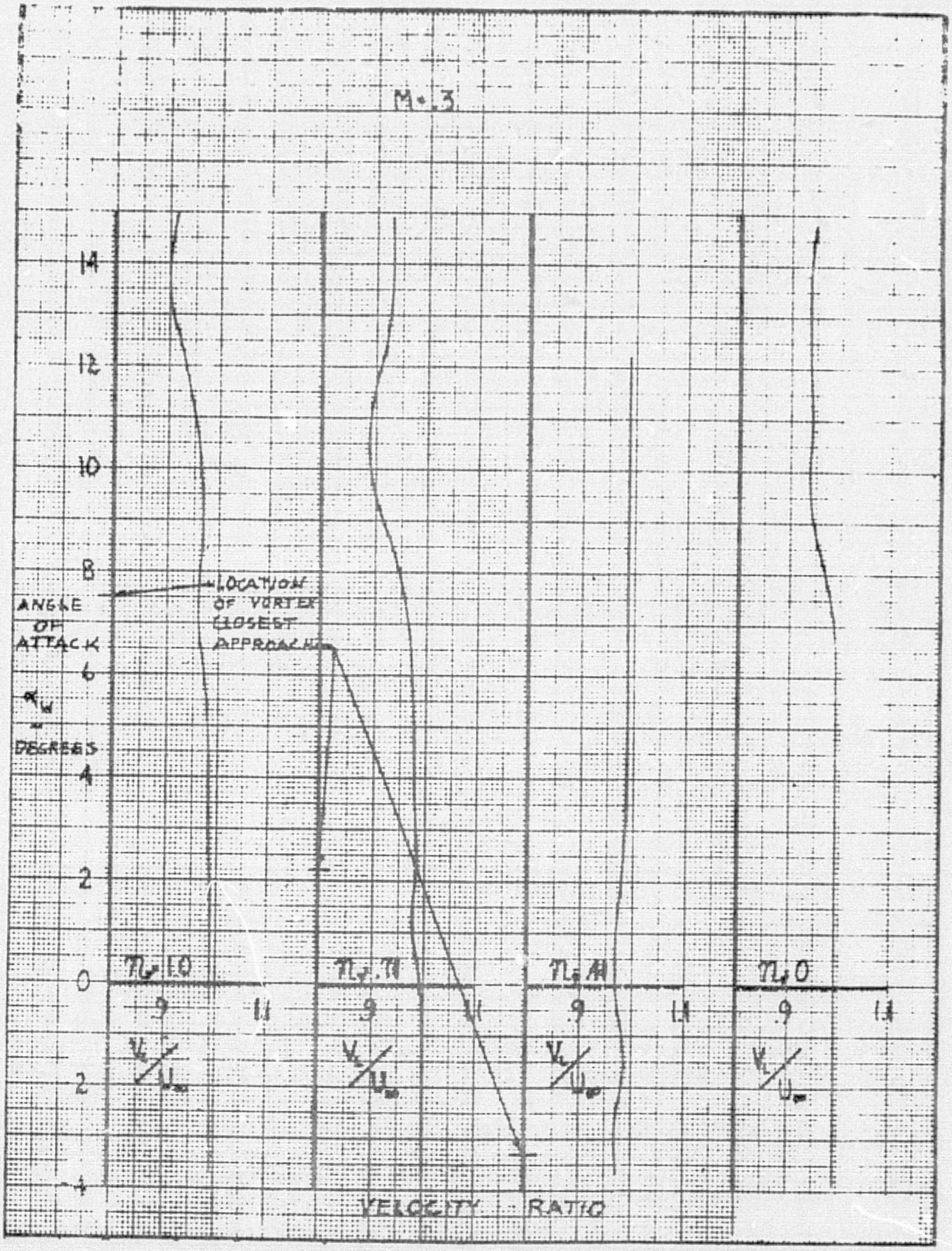

Figure 15. Velocity level at the 747 CAM tip fins, M = 0.3, i_o = 6°.

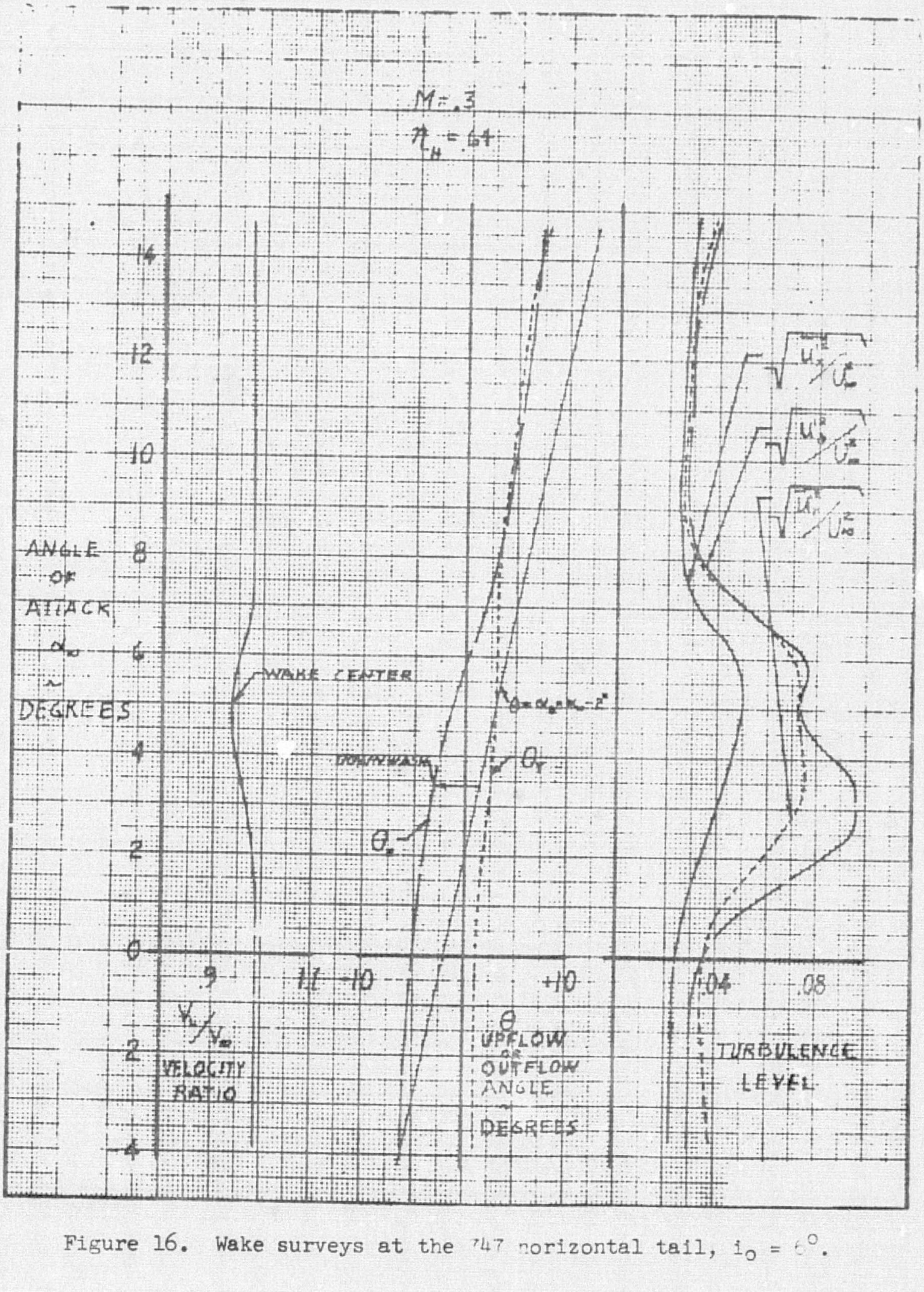

Figure 16. Wake surveys at the 747 horizontal tail, $i_o = 6°$.

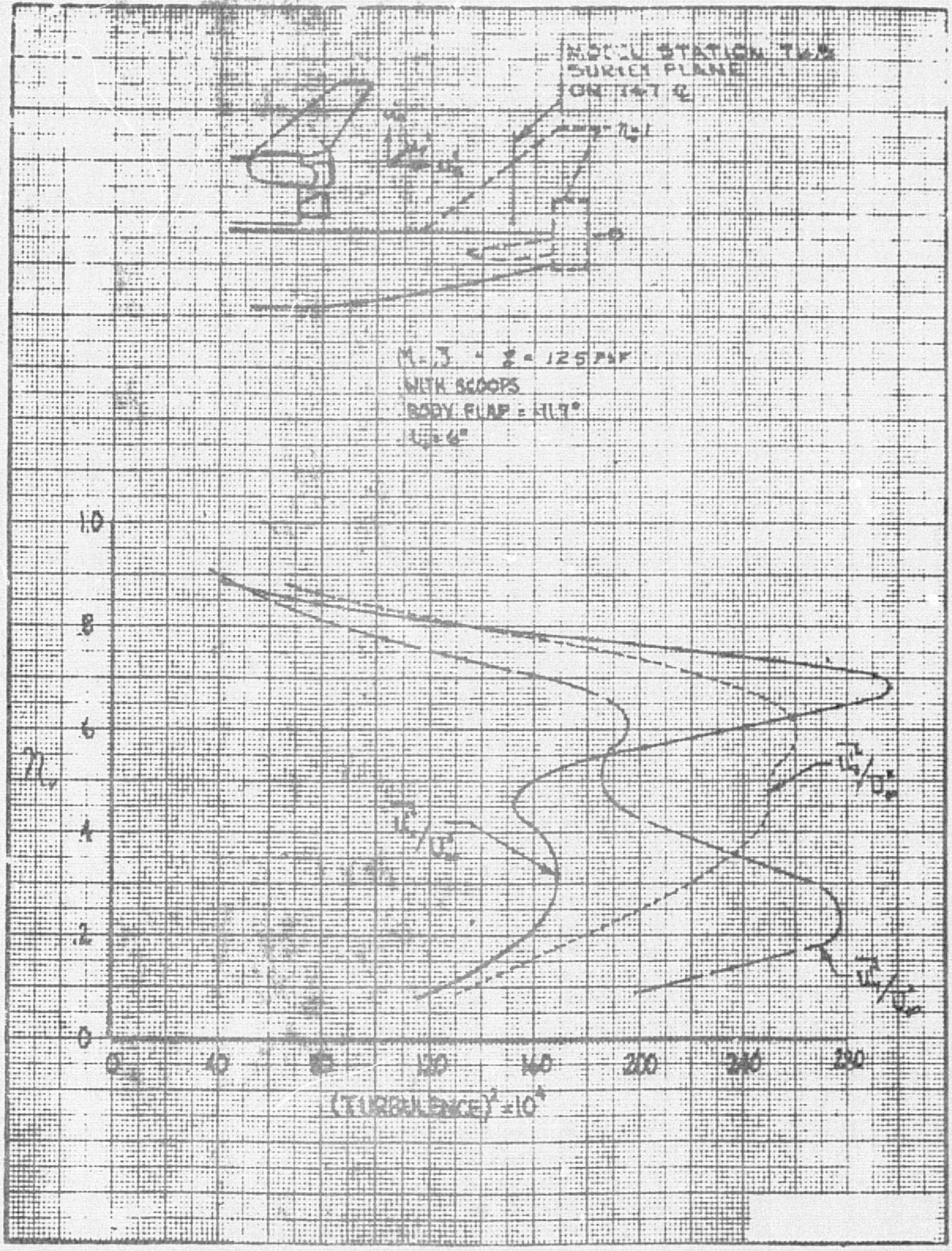

Figure 17. Comparison of longitudinal and lateral turbulence in the orbiter base wake at the 747 vertical.

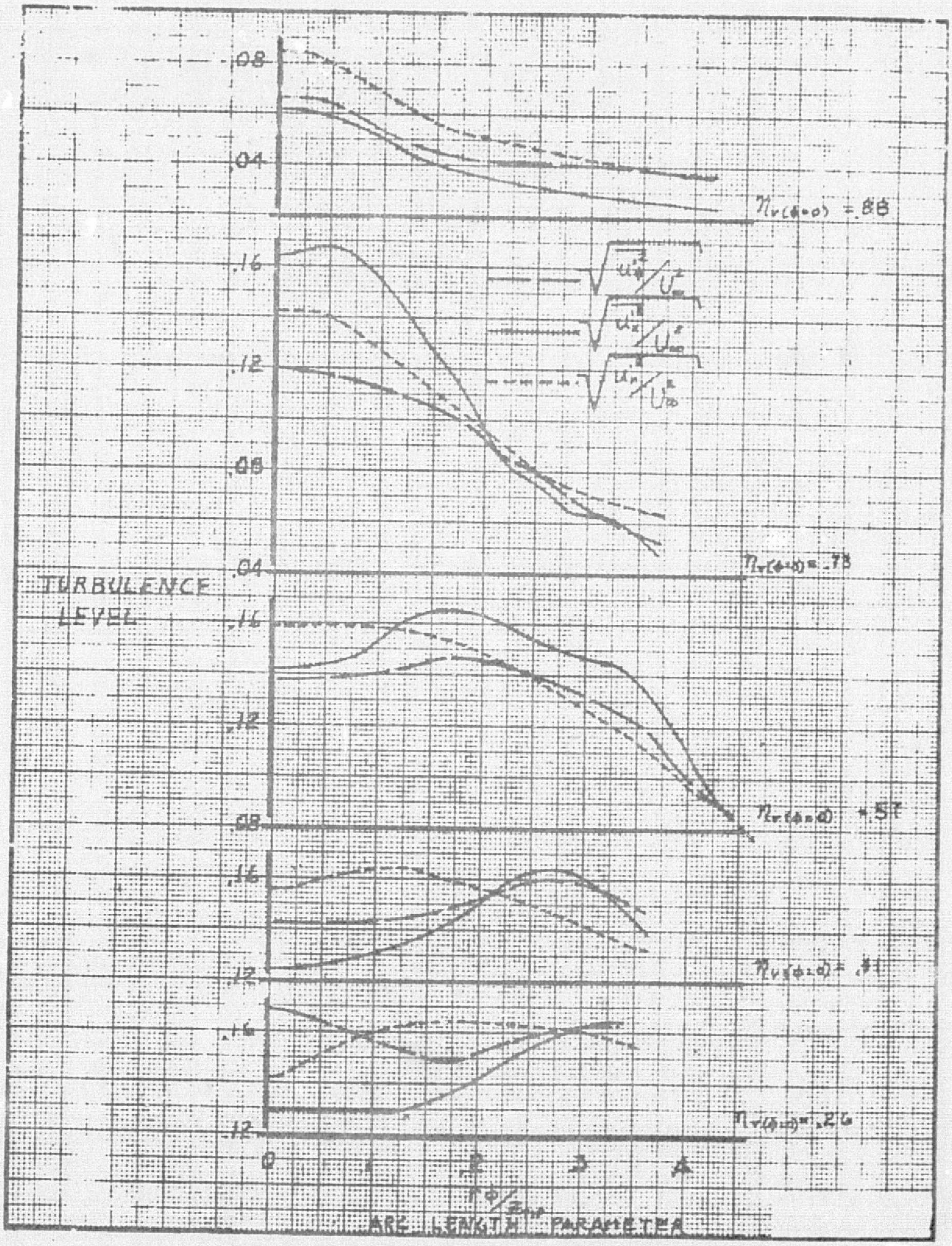

Figure 18. Turbulence level at the 747 vertical tail station $\delta_{BF} = -11.7^o$, $M = 0.3$, $\alpha_B = 6^o$, $i_o = 6^o$.

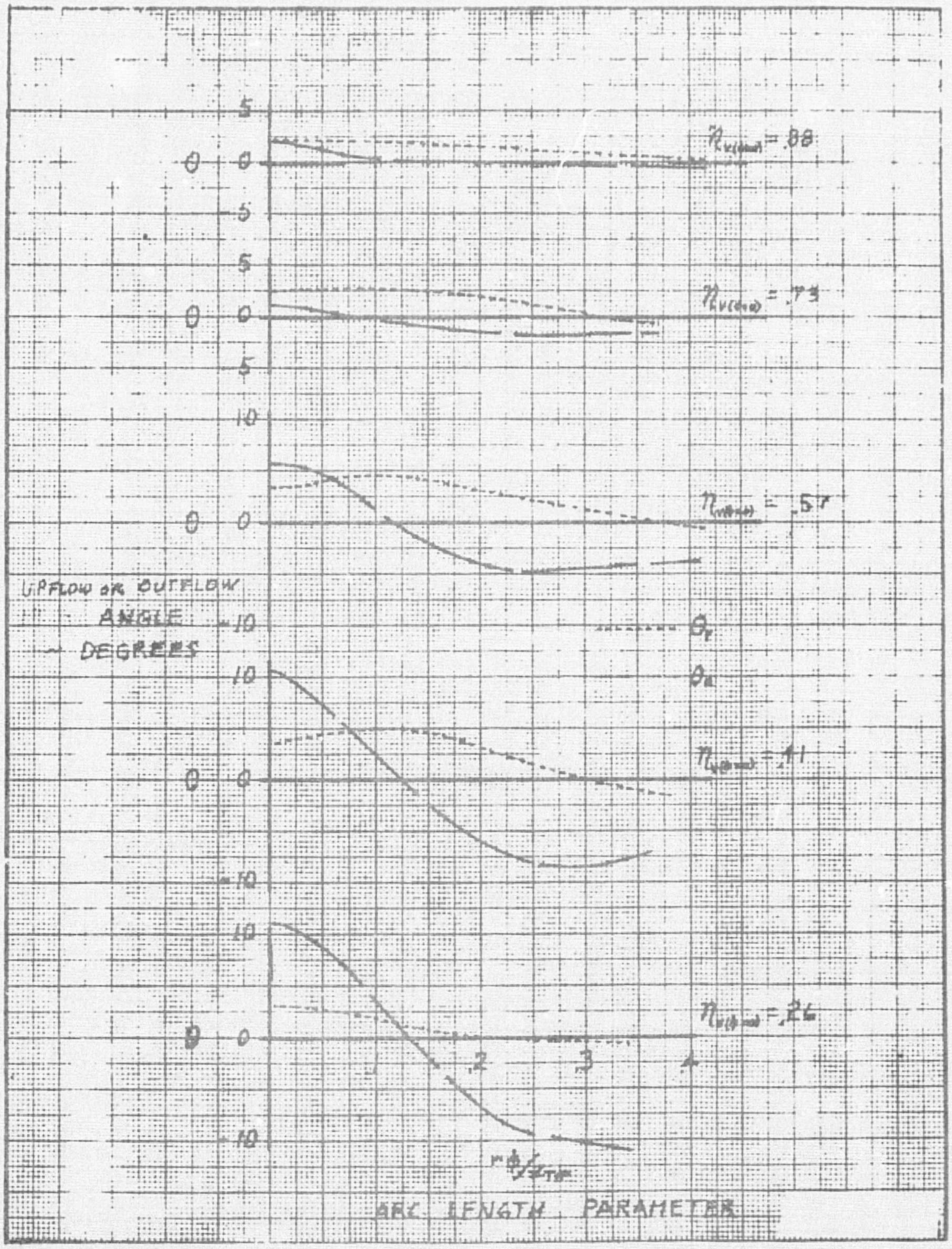

Figure 19. Flow angle at the 747 vertical tail station. $\delta_{BF} = -11.7^o$, M = 0.3, $\alpha_B = 6^o$, $i_o = 6^o$.

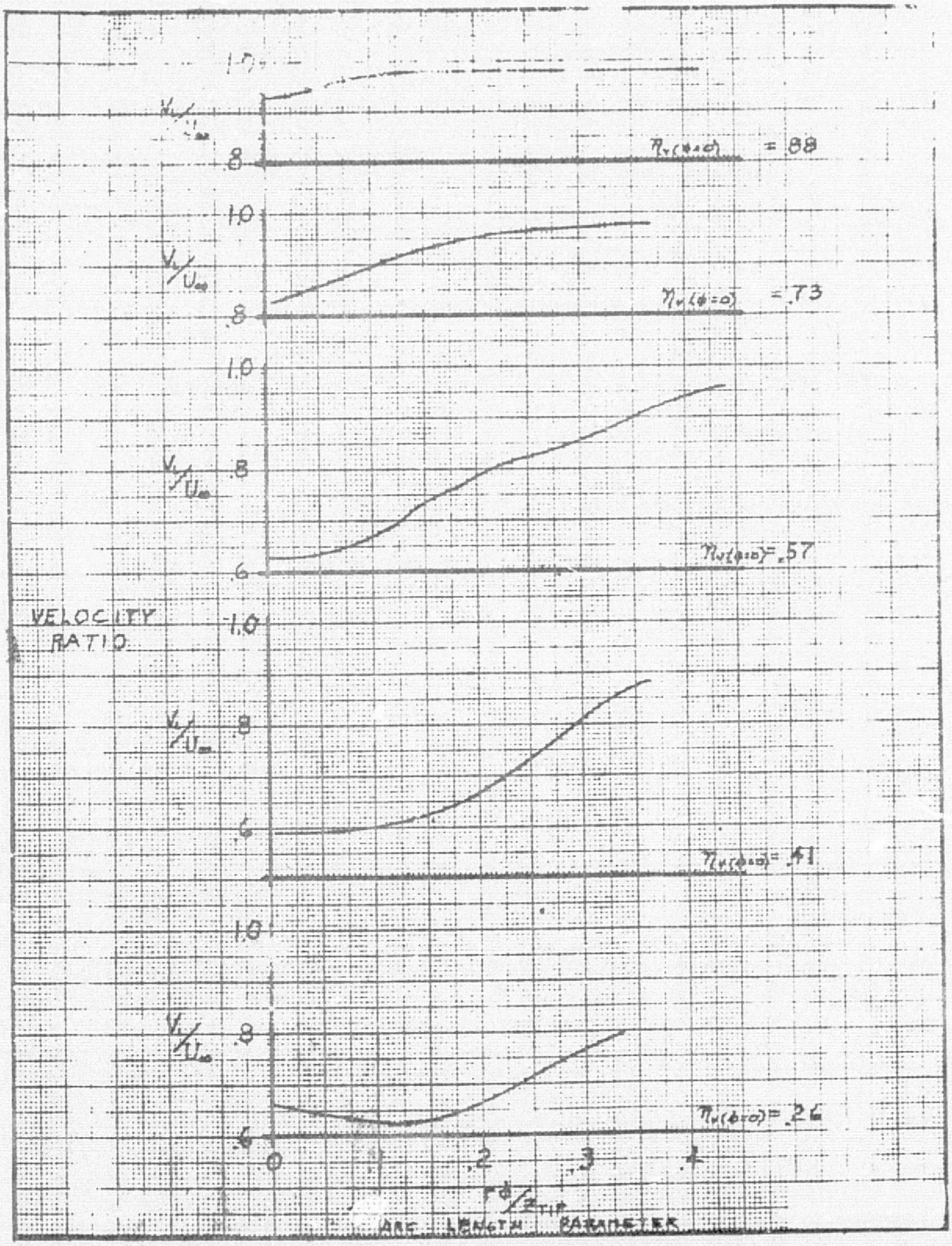

Figure 20. Velocity level at the 747 vertical tail stati[illegible]
$\delta_{BF} = -11.7^{\circ}$, $M = 0.3$, $\alpha_B = 6^{\circ}$, $i_o = 6^{\circ}$.